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POWER

DEVOTED TO THE GENERATION AND TRANSMISSION OF POWER

ISSUED WEEKLY

VOLUME XXXV

January 1 to June 30, 1912

124886
11/11/12

Hill Publishing Co.
505 PEARL STREET
NEW YORK

T5
.
P7
V.95

POWER

INDEX FOR VOLUME XXXV

JANUARY 1 TO JUNE 30, 1912

Explanatory Note.

Illustrated articles are marked with an asterisk (*). Book notices are denoted by a dagger (†). The cross references condense the matter and assist the reader, but are not to be regarded as conclusive. So, if there were a reference from "Boiler" to "Furnace" and if the searcher failed to find the required article under the latter word, he should look through the "Boiler" entries, or others that the topic might suggest, as he would have done had there been no cross reference. Letters are indexed under title or subject, general articles under writer's name as well. Not all articles relating to a given topic necessarily appear under the same entries.

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POWER

Vol. 35 NEW YORK, JANUARY 2, 1912 No. 1

What, ho! for the New Year.

Here she comes, and a banner year from every point of view, we warrant you.

To begin with, there are 366 days in this leap year of grace and exceptional opportunity, 1912. A good sign of full measure right from the go-off.

Now, then, what shall this year bring forth for you and yours?

Much depends on you, of course; in fact, we are almost willing to say, everything does. Whether you profit much or little by your opportunities, it is up to you—and you alone. As has been said before, no one is going out of his way to boost your game.

These opportunities seem to grow more and more numerous each year.

* * *

Every year finds the means of education closer at hand and more easy to obtain. There is small excuse for a person being short on "learning," these days.

For the men in the cities there are the evening grammar, trade and technical classes of the public schools, the institutes and the colleges. For the men in the smaller places there are the correspondence schools, the National Association of Stationary Engineers and the Institute of Operating Engineers, and for every man there is POWER!

* * *

New plants are being built. This means that more positions are being created for suitable men.

This whole year of 1912 is one big, long opportunity for *you* to prove that you are too good for your present position.

If you really are worthy of a bigger and better position, and you try earnestly enough to secure one, sooner or later you must succeed.

Remember, the higher, the fewer, which is another way of saying there is plenty of room at the top.

* * *

It is a common custom every year at this time to foot up the page and strike a partial balance in the ledger of life. That's where the expression about turning over a new leaf comes from.

Last year, at this time and on this page, we said something about forming good habits and breaking up bad ones. All those who succeeded in knocking out even one bad habit or in forming one good one, certainly have a fine credit page to boast about this year. All those who did not, have a new and convenient opportunity to try it over again, RIGHT NOW. And this year, the latter should make out much better because they have had one year more of experience by which to benefit.

* * *

POWER wishes you good luck, success in your good ambitions and a regular old cornucopia of prosperity for 1912.

Power System of the Pacific Mills

The Pacific Mills represent several textile industries located in North Lawrence and South Lawrence, Mass., and Dover, N. H. They employ some 9000 operatives and manufacture principally worsted and all-wool dress goods, printed and dyed cotton, worsted and silk fabric, and an addition now being built at South Lawrence will be, when completed, the largest print works in the world.

The entire Pacific Mills contain about 142 acres of floor space, and operate 404,360 spindles, 10,468 looms and 48 printing machines. There are 181 engines and turbines of 30,000 horsepower; 165 boilers of 36,000 horsepower and waterwheels of 7500 horsepower. There are also 625 electric motors aggregating 17,700 horsepower.

The different departments consume 10,000,000 pounds of wool, 20,000,000 pounds of cotton and 85,000 tons of coal per year. The finished product of the printing department alone is about 2000 miles of printed cotton cloth per week.

Increase in the power demand, due to the installation of modern high-speed machinery and the realization of the fact that the old power apparatus was getting to the end of its useful life, led to the decision to build a central power plant which is one of the largest isolated steam-turbine stations in the world devoted entirely to the textile industry.

The design and supervision of the construction were assigned to Charles T. Main, and the plant was the subject of a paper presented by Fred A. Wallace, master mechanic of the Pacific Mills Corporation, to a recent meeting of the Boston Society of Civil Engineers, the Mechanical and Electrical Engineers cooperating. It is to this paper and to photographs and information furnished by Mr. Wallace, with the kind consent of Walter E. Parker, agent of the Pacific Mills, that we are indebted for the facts and illustrations here presented.

Notwithstanding the fact that in the operations of slashing, dyeing, printing, etc., all of the steam exhausted by the prime movers necessary to run an installation of this kind could be used, it was determined on account of space considerations to place the station at one extremity of the property, as shown upon the accompanying map, and to run it condensing. It is evident that more would be gained in economy of operation in one large central station and in the valuable space, light, cleanliness and indemnity from fire risk by displacing the old equipment and the belt drives by simple electrical transmission.

The new station is located on a 3½-acre lot adjacent to the main-line tracks of the Boston & Maine Railroad and it is within reach of the river for condensing water and about one-quarter of a mile from the upper mill. It sends current at 2300 volts to four centers of distribution, the farthest of which is over two-thirds of a mile away. The position of the power plant relative to the various properties is indicated in Fig. 2, although the farther mills are still more distant than the sketch indicates on account of the section containing the Atlantic Mills, which has been removed in the grouping shown.

The managers of the Pacific Mills, with 181 engines and turbines aggregating some 30,000 horsepower and 165 boilers of 36,000 horsepower, concluded to meet the conditions created by the growing disability of their older equipment and the increasing demand for power by the erection of a central turbine condensing station to distribute power electrically to the mills, some at a considerable distance.

This is the largest central station yet built for textile work. It is expected that the economies of aggregation will compensate for the loss of the use of the exhaust steam for dyeing, preparation, heating, etc.

FIG. 1. POWER PLANT OF THE PACIFIC MILLS

A general view of the exterior of the station is afforded in Fig. 1, where the nearer building is the coal storage, the low central building with the monitor is the boiler room and the farther building is the turbine house.

THE BOILER ROOM

The boiler house is 140x87 feet and contains two rows of boilers with a 20-foot space between them for a firing floor, which is on a level with the yard and the turbine-room basement. The boilers are horizontal return-tubulars, 72 inches in diameter, and have 20-foot tubes.

The tubes are 3½ inches in diameter and the total heating surface of each boiler is about 1900 square feet; they are set in batteries of four boilers each, 12 boilers being on each side of the firing floor.

The shells are $\frac{13}{32}$ inch thick with quadruple-riveted joints, and by the Massachusetts rating can carry 160 pounds; they are set 30 inches from the grate, which has an area of 36 square feet. The shells are suspended by brackets and rods from an overhead structure which is carried on cast-iron columns so that none of the load comes on the setting. A large skylight with louvers in the sides extends the entire length of the room over the firing floor, thus giving excellent light and ventilation. The boilers are hand fired and 12 per cent. CO_2, 7 per cent. O and 0 per cent. CO are obtained as a usual result. No economizer is used and the flue gases escape to the chimney at 475 degrees. The firing floor is of vitrified brick on a concrete base. The toilet rooms contain modern shower baths with hot and cold water and individual lockers.

CHIMNEYS

Each group of 12 boilers has a chimney, 9 feet inside diameter by 200 feet high, built of common red brick on a concrete foundation carried on piles. Each chimney is constructed with a separate red-brick core wall and with a cast-iron cap at the top covering both the core and the shell; the portion for the core is separate from that of the shell so that they may move independently. Collector points for the lightning rods are attached to this cap.

The 12 boilers are connected to the two chimneys by a sheet-iron flue 6x10½ feet, having a double damper which is controlled by a regulator and maintains the boiler pressure constant within one pound. No provision is made for artificial draft.

PIPING

Steam is taken from the boilers by a 4-inch pipe and passes through superheaters set in the rear of the combustion chamber. The 4-inch pipes connect to a 10-inch main steam header from which

the steam passes to the different turbines and auxiliaries. The piping has been so proportioned as to get an average flow of about 7900 feet per minute. All piping is of the 250-pound standard, having the Van Stone type of joint and cast-steel fittings. All valves are steel body and bronze, fitted with outside screws. Two stop valves, two blowoff valves and two safety valves are fitted to each boiler.

Feed water is taken by duplex pumps from the condenser discharge at about 75 degrees Fahrenheit and passed through an exhaust-steam heater which raises the temperature to about 200 degrees Fahrenheit. This heater condenses the exhaust steam from the feed pumps, condenser pumps and engines and the engines which drive the exciter and a 75-kilowatt alternator.

Both the steam and the feed-water piping are so arranged that practically any portion of the plant may be isolated in case of accident or when it is desired to conduct a test. An ingenious arrangement for supporting the main 10-inch steam header consists of a steel yardarm held at the ceiling and carrying weights to balance the load of the pipe and the fittings. The piping was installed in place, with all its fittings, valves and flanges, but it was not connected to the boilers. The weights were moved to balance the entire system, and when adjusted the branches were bolted to the boilers, the entire line being supported without any strain. An excellent idea of the appearance of the boiler-room interior is given by Fig. 3.

Turbine Room

The turbine room is 126x79 feet, with a basement of the same size, and contains two 3850-kilowatt and two 750-kilowatt horizontal reaction steam turbines with jet condensers; two motor-driven exciter sets, one steam-driven exciter set and one 75-kilowatt engine-driven alternator with exciter. The turbines all run at 1800 revolutions per minute, with 150 pounds boiler pressure, 125 degrees superheat and 27 to 28 inches of vacuum.

The basement extends under the turbine room, is 14 feet high and is well lighted and ventilated. It contains all the boiler-feed pumps, condenser apparatus, fire pumps, heaters, etc.

Below the basement is a cistern 105 feet long, 10 feet wide and 20 feet deep which is connected by a 48-inch penstock to the river, which is about 1000 feet distant. This well supplies water for condensing and other uses about the station. One motor-driven centrifugal pump furnishes water under pressure for general purposes. The turbine-room basement floor is of concrete laid directly on the earth; the trenches for pipes, etc., have cast-iron covers.

The floor of the turbine room proper is of reinforced-concrete slabs on steel beams, which are supported independently of the turbine foundations, with a surface of red tiles about 9 inches square. The toilets for the engineers are similar to those of the boiler room and contain individual metal lockers and shower baths.

The condenser water, after passing the jet condensers, is returned to the river through a 48-inch penstock, having been raised in temperature some 15 or 20 degrees. The temperature of the river is but little above 32 degrees in the winter and reaches a maximum of 85 degrees in the summer.

The turbo-generators are cooled by air supplied through a shaft extending above the roof next to the chimney. In the shaft are 12 bags, each 26 feet long and 22 inches in diameter, made of cotton cloth of a weave suitable to admit air freely and yet to filter out the dust. The bags are cleaned every three months and about six quarts of material are collected.

All alternating current in the plant is generated three-phase, 60-cycle and 2300 volts, and is distributed in large blocks to the various groups of mills where a subdivision is made into smaller feeders. The major distributing mains are indicated in Fig. 2. The large power feeders to the upper and lower mills are really tie lines between stations, as one of these already has generators installed and the other will have in the future. The output of each generator is measured by an integrating wattmeter so that the total energy generated is known. The power sent to each group of mills is known, as each feeder circuit has its integrating meters. The power used for

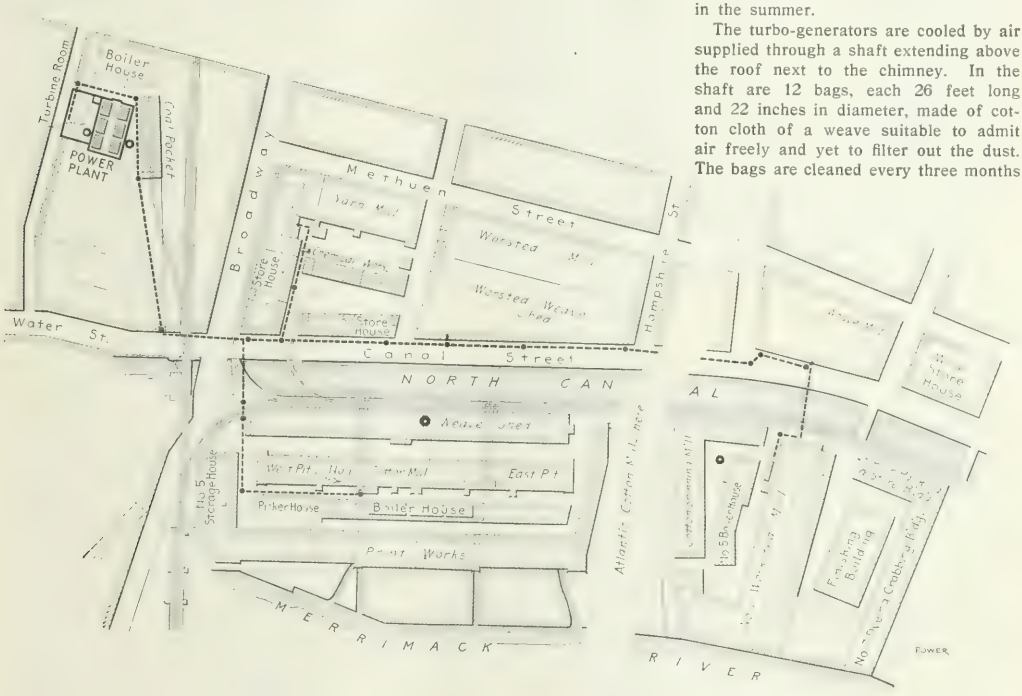


Fig. 2. General Layout of the Mills, Showing Location of Power Plant

driving the motor exciters, coal-handling apparatus, pumping, lights, etc., about the station is also metered. Each circuit is equipped with indicating meters so that the instantaneous load and current may be obtained.

Coal Storage and Handling

The coal is stored in a concrete pocket which is reached by a trestle from the Boston & Maine tracks. It is 210x52 feet and holds 5000 tons, with a storage depth of 20 feet. Cars are pushed up this trestle and dumped either into a main or an auxiliary pocket. The floor of the main pocket is 10 feet below the yard level and that of the auxiliary pocket is at the yard level so that coal may be taken from the auxiliary by automobiles if any accident should happen to the regular coal conveyer. A 6-inch pipe from the fire system is connected to the bottom of the coal storage so that in case of fire the whole area can be flooded as a last resort.

The coal-conveying system is a monorail grab bucket traveling at about 400 feet per minute and carrying 2000 pounds; the length of the average haul is about 350 feet. The working capacity of the bucket is about 12 tons per hour, allowing for weighing each load. A view of the conveyer and of the overhead track between the coal storage and the boiler rooms is shown in Fig. 5. One man handles all the coal at a cost of less than 2 cents per ton, including labor, repairs, supplies and electric current.

The load factor of the station is practically 33⅓ per cent. and, although the load is quite constant for 5½ hours in the morning and 5 hours in the afternoon, it starts and stops very abruptly, which makes it difficult to manage the furnace fires economically at those times.

All fires are banked at night except those required to run on overtime work or on the regular lighting circuits. The ashes are weighed before being taken from the boiler house and the percentage of ash is entered on the weekly report. Every carload of coal is sampled and a chemical analysis made for fixed carbon, volatile, ash, moisture and B.t.u.; this record is studied carefully in its relation to power-house results. The fires are cleaned at night by the night shift and the ashes are wheeled in barrels to the ashpile outside the building; they are sold for filling. At present four firemen and a boss fireman are on day duty, each fireman firing four 190-horsepower boilers. Three firemen are on duty during the night, two to clean the fires of 14 boilers, the third cleaning two boilers and being responsible for the station.

The help for the turbine room consists of the chief engineer, who has other duties outside the station, two operating men, one oiler for auxiliary apparatus and one cleaner, who is also a spare fireman.

The acceptance test of the turbines showed the following results with 150 pounds boiler pressure, 125 degrees superheat, 28 inches vacuum with barometer at 30 inches and condensing water at 70 degrees:

Load, Per Cent.	3850 Kilowatt Unit	750 Kilowatt Unit
50	17.83	.....
75	15.5	18.92
100	15.4	17.84
125	15.16	16.63
140	15.84	.....

The auxiliaries, including the condensers and feed pumps, use about 12 per cent. as much steam as the main unit. This test was made with the 3250-kilowatt turbine delivering 3810 kilowatts. Two condenser pumps, one feed pump and the Holly drip system were the auxiliaries which required the 12 per cent. The cost for operating an average week on 3600 kilowatts under the conditions which have obtained during the past year are as follows:

Turbine-room labor, five men and superintendence	$99.85
Boiler-room labor, eight men	99.15
Fuel, $4.25 per long ton in pocket	880
Oil, waste, supplies and repairs	37.05
Total operating expenses per week	1116.05

During the week 204,780 kilowatt-hours are generated, giving a cost per kilowatt-hour of 0.545 cent. In a few months the load will be increased to about 6100 kilowatts, thus giving a weekly output of approximately 340,000 kilowatt-hours. The two large turbines will then be run, leaving the two smaller ones as spares. To operate the station under these conditions will cost:

Turbine-room labor, five men and superintendence	$99.85
Boiler-room labor, nine men	108.95
Fuel, $4.25 per long ton in pocket	1483.25
Repairs and supplies	58.60
Total operating cost per week	$1750.65
Operating cost per kilowatt-hour	0.515 cent

The station as it now stands, with its 8000-kilowatt normal capacity of generators, cost, with the land and everything up to and including the switch-

Fig. 3. The Boiler Room

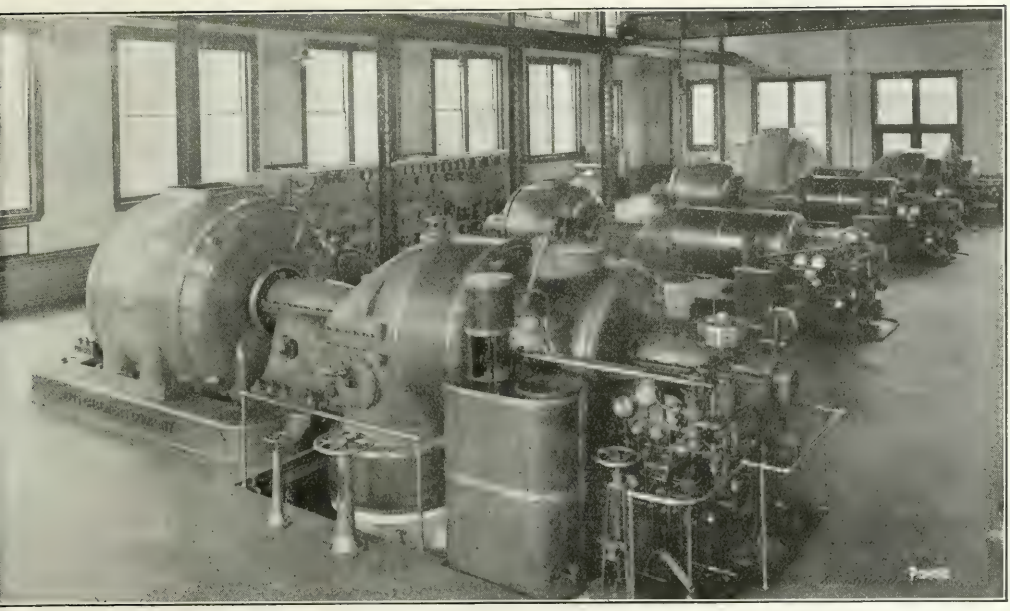


FIG. 4. THE GENERATING ROOM WITH ITS FOUR TURBINE UNITS

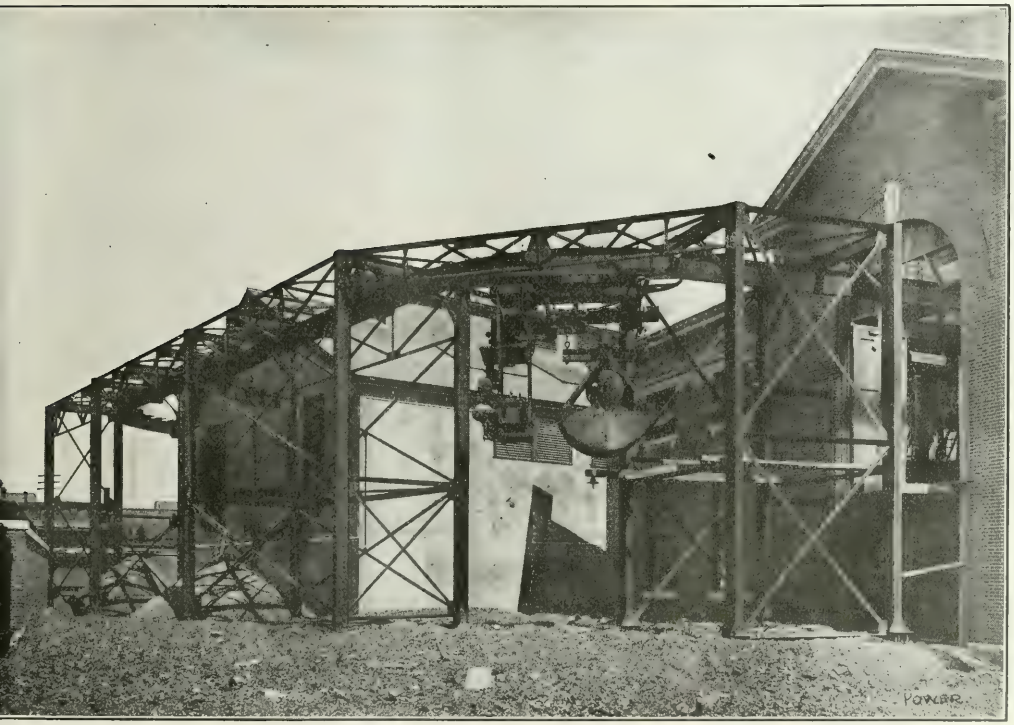


FIG. 5. MONORAIL GRAB BUCKET OF COAL-CONVEYING SYSTEM

board, a little less than $90 per kilowatt. Taking the fixed charges on this sum at 11 per cent., they become $79,200 per year, or $1523.08 per week. With the station generating 340,000 kilowatt-hours per week, the fixed charges will be 0.448 cent per kilowatt-hour.

Thus the total cost per kilowatt-hour at the switchboard for the 6100-kilowatt load on the plant will be

$$0.515 + 0.448 = 0.963 \text{ cent}$$

The same figures, if this plant should be operated at its full capacity of 8000 kilowatts, would be 0.841 cent for the operating conditions of 6100 kilowatts; the cost is divided as follows:

	Per Cent.
Labor	6.4
Fuel	45.5
Repairs and supplies	1.8
Fixed charges	46.3

The principal objects in view in the design and operation of this station have been simplicity and reliability, and these have been obtained. Many of the requirements which are supposed to make for refinement and efficiency have been omitted, particularly in the boiler room, where simplicity was especially desired and was obtained as indicated by the photograph.

Deterioration of Coal in Storage*

By H. C. Porter and F. K. Ovitz

The tests showed that coal does not deteriorate, when exposed for a considerable time to the weather, nearly as much as is generally supposed. Also under-water storage has practically no detrimental effect upon coal, except for increasing the moisture.

Spontaneous heating is also discussed and suggestions given for preventing it.

*Presented at a joint meeting of the New York section, American Chemical Society, the American Electrochemical Society, and the Society of Chemical Industry.

Not many years ago, coal was commonly regarded as extremely unstable. E. C. Pechin, in 1872, speaking before the American Institute of Mining Engineers, said: "Coal suffers materially by storage; especially in the case of bituminous and semibituminous coals, an exposure of only two weeks causing a loss of carbon to the extent of 10 to 25 per cent." Similar views have been held in much more recent times; for example, in a paper before the United States Naval Institute in 1906 the statement was made: "The pressure of the weight of coal causes gases to be evolved; these gases constitute the chief and only value of the coal in that they furnish the heat units. It is claimed that if a ton of fine bituminous coal be spread out on a concrete pavement in the open air in the vicinity of Key West, Fla., for one year, it will lose all its calorific properties."

In 1907, a German gas-works engineer claimed to have found that moist fine coal sustained an average loss per week of 1.7 per cent. Other statements like these are to be found in recent literature, but probably the great majority of chemists and engineers today hold no such exaggerated ideas. There is, however, a well defined suspicion in the minds of many that sufficient loss of volatile matter and deterioration by oxidation does occur in coal to be of industrial importance; and for that reason the investigations herein described were undertaken by the Bureau of Mines to determine accurately the extent of the deterioration in different kinds of coals.

Deterioration by Oxidation

First, a study was made in the laboratory of the loss of volatile matter from crushed coal during storage. A number of samples (20 lb. each) representing a variety of types from widely separated fields, were broken to about ½-in. size and immediately placed in glass bottles while in the mine. At the laboratory the accumulated gas was withdrawn and a free continuous escape of the volatile products was permitted at atmospheric pressure and temperature. The results of these experiments have been published in technical paper No. 2 of the Bureau of Mines, entitled "The Escape of Gas from Coal," and will therefore not be given here in detail. Suffice it to say that while several coals evolved methane in large volumes, especially in the early period after mining, the coal suffered in one year a maximum loss in calorific value from this cause of but 0.16 per cent.

At the instance of the Navy Department, however—which is a purchaser of coal to the extent of two or three million dollars annually, and stores large quantities in warm climates for long periods of time—more elaborate tests were undertaken to determine the total loss possible in high-grade coal by weathering. The extent of the saving to be accomplished by water submergence as compared to open-air storage was a point to be settled, and there had also arisen the question as to whether salt water possessed any peculiar advantage over fresh water for this purpose.

The tests conducted by this department were carried out as follows: Four kinds of coal were chosen—New River on account of its extensive use by the navy; Pocahontas as a steaming and coking coal used extensively in the East, and as being also the principal fuel used in the Panama Canal work; Pittsburg coal as a type of rich coking and gas coal, and Sheridan, Wyoming, sub-bituminous or "black lignite"—a type much used in the West. With the New River coal, 50-lb. portions were made up out of one large lot, which had been crushed to ½-in. size and well mixed. These portions, confined in perforated wooden boxes, were submerged under sea water at three navy yards, differing widely from each other in climate conditions, and 300-lb. portions from the same original lot were exposed to the open air, both out of doors and indoors, at the same places.

The Pocahontas coal was tested only at one point, the Isthmus of Panama, the run-of-mine coal being placed in a 120-ton pile, exposed to the weather. Pittsburg coal was stored as run-of-mine in open outdoor bins of 5 tons capacity, at Ann Arbor, Mich., also in 300-lb. barrels submerged under fresh water. The Wyoming sub-bituminous was stored at Sheridan, both as run-of-mine and slack in outdoor bins, holding three to six tons each.

Every test portion was sampled each time in duplicate and in all cases except the outdoor pile at Panama and the 300-lb. open-air piles of New River coal, the sampling was done by rehandling the entire amount. In the excepted cases mentioned it was not thought fair to disturb the entire lot, and therefore at Panama a vertical section of 10 tons only was removed each time (eight samples being taken from the 10-ton section), while in the case of the outdoor lots at the navy yards a number of small portions, well distributed, were taken from each pile, mixed, and quartered down. Small lots and a fine division were conditions purposely adopted with the New River coal so as to make the tests of maximum severity.

Moisture, ash, sulphur and calorific-value determinations were made on each sample, the latter by means of the Mahler bomb calorimeter and a carefully calibrated Beckman thermometer. The calorimetric work on all except the Sheridan tests was done throughout by one man and with the name instru-

ment. Furthermore, all the calorific values in the tables were calculated to a comparable unit basis, that of the actual coal substance free of moisture, sulphur and corrected ash.

Results of Tests

The results show in the case of the New River coal less than 1 per cent. loss of calorific value in one year by weathering in the open. There was practically no loss in the submerged samples and fresh water seemed to preserve the qualities of the coal as well as salt water. There was almost no slacking of lump in the run-of-mine samples and the crushed coal in all cases deteriorated more rapidly than the run-of-mine.

The Pocahontas run-of-mine in a 120-ton pile on the Isthmus of Panama during one year's outdoor weathering lost less than 0.4 per cent. in heating value, and suffered little or no physical deterioration of lumps.

The Pittsburg gas coal during six months' outdoor exposure suffered no loss whatever of calorific value, measurable by the calorimetric method used, not even in the upper layer of the bins.

The Wyoming coal lost as much as 5.3 per cent. in one of the bins during two years and nine months; 3.5 per cent. of which was lost in the first three months. There was bad slacking and crumbling of the lumps on the surface of the piles, but where the surface was fully exposed to the weather this slacking did not penetrate more than 12 to 18 in. in the whole period.

No outdoor-weathering tests have been made by the bureau on Illinois coal. Thorough tests, however, on this kind of coal have been reported by Prof. Parr, of the University of Illinois, and by A. Bement, of Chicago, both of whom find from 1 to 3 per cent. calorific loss in a year by weathering. Mr. Bement reports a slacking of lumps (in tests on small samples) of over 80 per cent. in one case and about 12 per cent. in another. It is probable that in this case, as with the Wyoming test, the slacking in a large pile would not penetrate far from the surface.

Storage under water unquestionably preserves the heating value and the physical strength of coal, but it necessitates firing wet coal, and therefore means evaporating an amount of moisture varying from 1 to 15 per cent., according to the kind of coal. This factor is an important drawback to under-water storage with coals such as Illinois and Wyoming, which mechanically retain 5 to 15 per cent. of water after draining; but in the case of the high-grade Eastern coals, if firemen are permitted, as is ordinarily the case, to wet down their coal before firing, then the addition during storage of the 2 or 3 per cent. moisture which these coals retain would be of little consequence. Submergence storage is an absolute preventative of spontaneous combustion, and on that account alone its use may be justified with some coals, but merely for the sake of the saving to be secured by avoidance of weathering there does not seem to be good ground for its use.

Spontaneous Combustion

Losses in coal due to spontaneous heating are a much more serious matter. Oxidation begins at ordinary temperatures in any coal, attacking the surfaces of the particles and thus slowly developing heat. In a small mass of coal this slowly developed heat is readily dissipated by radiation, with no rise in temperature. If radiation is restricted, however, as in a large pile densely packed, the temperature slowly rises. Now, the curve of oxidation rate plotted against temperature, rises with great rapidity, and when the storage conditions are such as to allow a certain point (near 100 deg. C.) to be passed, the rate of oxidation is great enough ordinarily so that the heat developed over-balances the heat radiated and the temperature will rise to the ignition point if the air supply is adequate. The importance therefore can be seen of guarding against even moderate heating in the coal either from internal spontaneous causes or by radiation from external sources. Increased loss of heating value and of volatile matter occurs at moderately increased temperatures even though the ignition point is not reached.

The amount of surface exposed to oxidation in a given mass depends on the size of the particles and increases very rapidly as the fineness approaches that of dust. Dust therefore is dangerous in a coal pile, particularly if it is mixed with larger-sized coal which forms air passages to the interior. Spontaneous combustion is brought about by slow oxidation in an air supply sufficient to support the oxidation but insufficient to carry away all the heat formed. There is a wide variation among coals in friability. In comparative rattler tests under certain standard conditions, Pocahontas, New River and Cambria County coals produced nearly twice as much dust (through a ⅛-in. screen) as a sample from the Pittsburg seam. This is a large factor in spontaneous combustion. Mixed lump and fine (run-of-mine) with a large percentage of dust, and piled so as to admit to the interior a limited supply of air, make ideal conditions for spontaneous heating.

High volatile matter does not of itself increase the liability to spontaneous heating. A recent circular letter of inquiry on spontaneous combustion sent by the Bureau of Mines to more than 2000 large coal consumers in the United States has brought 1200 replies, of which 260 report instances of spontaneous combustion, 220 of them naming the coal. Of these 220, ninety-five were with semi-bituminous, low-volatile coals of the Appalachian region, and 55 with Western and Middle Western coals. This result shows at least no falling behind on the part of the "smokeless" coals and no cause for placing special confidence in these coals for safety in storage.

A serious fire in cinder filling under a manufacturing plant in Pittsburg was recently investigated and all the evidence pointed to spontaneous combustion as the cause, induced by external heat radiated from a furnace. The cinders contained 40 per cent. carbon. A similar fire occurred two years ago in cinder filling under a smelting plant on Staten Island in which the cinders contained 33 per cent. carbon; damage amounting to $20,000 was done. The cause was not definitely determined, but from the reports of the insurance adjusters spontaneous heating appears to be the most plausible explanation. The volatile matter in the material could not have been a factor in these cases.

Pocahontas coal gives considerable trouble with spontaneous fires in the large storage piles at Panama. It is reported also by several large byproduct-coke concerns to be more troublesome in this respect than their high-volatile gas coals. The high-volatile coals of the West are, to be sure, usually very liable to spontaneous heating, but they owe this property to the chemical nature of the substances which compose the coal rather than to the amount of volatile matter.

Moisture and Sulphur Influences

The influence of moisture and that of sulphur upon spontaneous heating of coal are questions much discussed, not very much actually investigated, and certainly not yet settled. Some claim that in the laboratory, dry coal oxidizes more rapidly than moist, but the weight of opinion among practical users of coal is that moisture promotes spontaneous heating. The observation by the Bureau of Mines of many actual cases has not developed any instances where moisture could be proved to have had such an effect. Sulphur, on the other hand, has been shown by these investigations to have, in most cases, only a minor influence. In a number of actual cases, samples of the heated coal from areas where the heat was greatest have been analyzed, both for the total sulphur and that in the sulphate form, and the unoxidized sulphur was in no case less than 75 per cent. of the average total sulphur in the original; in other words, not more than one-quarter of the total sulphur entered into any heat-producing reaction. The possibility remains, however, that all of the sulphur which was oxidized was concentrated in one pocket of moist, flaky pyrites, and thus sufficient heat was developed in one spot

to act as an igniter. On the other hand, a Boston company, using Dominion (Nova Scotia) coal containing 3 to 4 per cent. sulphur, has had much trouble with spontaneous fires in storage, but a number of samples taken by the bureau from exposed piles of this coal in which heating had occurred showed that 90 per cent. of the sulphur was still unoxidized. Experiments in the laboratory, by passing air over coal at 120 deg. C., have developed enough heat to ignite the coal and no change was found in the form of the sulphur. While not entirely conclusive, these results point to a very minor contribution, if any, on the part of sulphur to spontaneous heating in coal.

Freshly mined coal and even fresh surfaces exposed by crushing lump coal exhibit a remarkable avidity for oxygen, but after a time they become coated with oxidized material, so that the action of the air becomes less vigorous. It is found in practice that if coal which has been stored for six weeks or two months and has already become somewhat heated, be rehandled and thoroughly cooled by the air, spontaneous heating rarely begins again. A large power plant in New York crushes its coal to pass through a 4-in. screen immediately after unloading from the barges, the fine coal and dust (50 per cent. or more) being left in the coal to be stored. This freshly crushed coal is elevated to iron hopper-shaped bunkers directly over the boilers and the air temperature in these often reaches 100 deg. F. As the coal hangs on the sloping sides sometimes three or four months at a time, it seems hardly surprising that some of the bunkers are on fire practically all of the time.

Safety Precautions for Coal Storage

With full appreciation of the fact that any or all of the following recommendations may under certain conditions be found impracticable, they are offered as being advisable precautions for safety in storing coal whenever their use does not involve an unreasonable expense:

1. Do not pile over 12 ft. deep or so that any point in the interior will be over 10 ft. from an air-cooled surface.
2. If possible, store only lump coal.
3. Keep the dust out as much as possible; therefore reduce the handling to a minimum.
4. Pile so that the lump and fine coal are distributed as evenly as possible; not, as is often done, allowing lumps to roll down from a peak and form air passages at the bottom.
5. Rehandle and screen after two months.
6. Keep away external sources of heat even though they are moderate in degree.
7. Allow six weeks' "seasoning" after mining before storing.
8. Avoid alternate wetting and drying.
9. Avoid admission of air to the interior of the pile through interstices around foreign objects, such as timbers or irregular brickwork; also, through porous bottoms, such as coarse cinders.
10. Do not try to ventilate by pipes as more harm than good is often done.

Status of the Small Steam Turbine*

By W. J. A. London

The paper points out some of the uses to which small turbines are adapted, compares electric, reciprocating-engine and turbine drives for these purposes; shows that the water rate of small steam turbines can be improved, but at the expense of greater weight, floor space and first cost; suggests the use of Napier's formula for a simple determination of the steam rate.

The new uses for the turbine and the fact that all builders of small turbines are turning out more work every year are sufficient evidence that there must be some very good reasons for this change in ideas. In studying the early history of the steam turbine, it will be found that the greatest factor tending to retard the advancement of the turbine was not the turbine itself, but the difficulty of finding a suitable and satisfactory machine that it could drive. The troubles experienced with generators in the early days are ancient history, and with the applications of the small turbine for auxiliary purposes, history is again repeating itself. The small turbine has been established for a long time, but many difficulties have been encountered in the satisfactory production of efficient generators, pumps and blowers in order to make the whole unit a commercial success. The makers of this apparatus have appreciated the indisputable advantages of the turbine drive and have laid themselves out to cater to this field, resulting in commercially satisfactory machines to fill the place of practically all engine- and electric-driven auxiliaries in the past.

Considering the three types of prime movers for auxiliary machinery, there are the electric drive, the reciprocating engine and the steam turbine. The motor drive may sometimes be most efficient, but this is questionable when exhaust steam can be used. It is the simplest form of drive, is clean and can be installed in a simple manner. There are no steam pipes, pet-cocks or other encumbrances. Against the electric drive, there have to be faced the disadvantages of probable electrical leakages and the serious accidents resulting therefrom.

While in Europe the electric drive has been the most popular for many years on account of the use of the economizer in those countries in place of feed-water heaters, many of the latest stations are now changing over to steam drive for their auxiliaries. Reliability in auxiliary machinery is of vital importance and it is obvious that, by taking the energy from the primary source of power and from the supply least likely to fail, namely, the boiler, the chances of breakdown are minimized.

Advantages of Turbine over Reciprocating Engine

For steam-driven auxiliaries the choice is between the reciprocating engine and the turbine. The reciprocating engine naturally requires more attention than a motor, cylinder lubrication being almost invariably necessary, resulting in the discharge of oil to the heater or to the condenser, and therefore to the boiler. Again, there being more working parts, the wear of reciprocating engines is greater than in a motor. With regard to the steam turbine, this approaches the simplicity of the motor as nearly as it is possible for a steam unit to do. The number of bearings is the same and the duties on the bearings are approximately the same; therefore the attendance of the two units can be said to be about equal. In favor of the turbine over the reciprocating engine, are the elimination of pet-cocks and the danger of water-hammer and internal lubrication, and, with the introduction of superheated steam to modern plants, the consensus of opinion at the present day seems to be that the turbine is by far the more suited to this work than the reciprocating engine. The simplicity of the turbine, and its limited amount of necessary attendants, is a factor bearing directly on station costs in view of the cheaper grade of labor permissible.

One great drawback to the turbine for years has been the ignorance of the average engineer as to the mechanical construction of these machines, to-

gether with a prejudice against their apparently high speeds. The turbine maker is probably a great deal to blame for this condition of affairs, it having been the policy to keep the construction of the machines dark. A broader view, however, exists at the present time, and consequently engineers are becoming more experienced and now feel themselves competent to take care of these machines without having to send to the manufacturer for the smallest repair or adjustment that may be necessary.

Efficiency of Small Turbine

With regard to the efficiency of the small turbine, both with regard to a comparison of different types and to a comparison with motors or reciprocating engines, the writer would like to enlarge on the real meaning of efficiency. The question of water rate does not cover the situation. In a 5000-kilowatt turbine, the consumption of each pound of steam per kilowatt means probably $2400 per year. In a small turbine, a difference of one pound per horsepower in a 100-horsepower machine means for the same period of operation, $48 per year.

Practically all small turbines on the market at the present time can be improved in water-rate efficiency. This can be done by increasing the speed in revolutions per minute or by increasing the peripheral velocity, using larger wheels, or by an increased number of stages. All these points mean additional complication, additional weight and higher first cost.

For the sake of argument, a single-stage turbine with a 2-foot wheel, if increased 3 inches in diameter will bring down the water rate from 38 to 36 pounds; in other words, a saving of 5 per cent. would mean an increase in weight of the whole turbine of about 17 per cent. The increase in floor space would be 10 per cent., and the increase in the cost or selling price would be approximately 15 per cent. The point then for the designer to consider is where to draw the line between absolute water rate and commercial efficiency.

It is obvious that a comparatively slow-speed machine will give less trouble, not only to itself but to the other end of the apparatus, and a breakdown due to over-sensitiveness on the part of the turbine of high efficiency will soon run away with the money saved by the increased efficiency.

For example, assume a 100-horsepower turbine of a slower speed to consume 2 pounds more per horsepower than another, which means an additional cost of about $96 per year. This $96 per year means 4 cents per hour, and the difference between the cost of unskilled labor necessary for the one machine and the skilled labor necessary for the attention of the other generally amounts to much more than this. Assuming the case of an exciter running a large engine, one hour's shutdown per year at the rate of 3 cents per kilowatt-hour will more than pay for this additional coal bill.

Supposing again the turbine is to run the condensing apparatus, the difference in steam consumption of a 5000-kilowatt machine running over from condensing to noncondensing will take a running period of only six hours to pay for the $96 additional coal consumed. This question of reliability is, to the writer's mind, not sufficiently emphasized, and should be considered an absolutely direct part of the efficiency factor, and the average engineer is now sufficiently well versed in the construction of steam turbines to be able to determine for himself what he can expect in overall efficiency when given the water rates and the construction of the various machines.

Not a "Steam Hog"

With reference to the actual water rates obtained, the idea existing among many engineers that the turbine is a "steam hog" is entirely erroneous, as will be shown. Of course, examples can be found every day where conditions are such that if economy is a factor to be considered, poor judgment was shown in the first instance in ever installing a turbine. This state of affairs is not by any means confined to the small turbine; many examples of it may be seen in the larger marine installations.

In practice, the engineer does not care about turbine water rates. He is interested in his overall water rates per air, electrical or water horsepower, as the case may be, and instead of always criticizing the turbine end, it is the other end that for many years has needed reforming.

Water-rate Efficiency

The work of the builder of the other apparatus has resulted in a unit which can hold its own against all competition, not only in reliability but in actual water-rate efficiency. It has been a practice for years to run gas blowers at turbine speeds, but as there were no turbines in the earlier days, the belt drive was adopted. Later installations are using the direct turbine drive with the same blower speed as previously, which gives a better overall efficiency. A fair figure at the present time for a modern gas-plant operating with 125 pounds steam noncondensing, with a turbine of 100 horsepower, is about 70 to 80 pounds per air horsepower with a blower pressure of 22 inches.

In some tests quoted by Mr. Morehouse in a paper read before the Southwestern Gas & Electric Co. on an engine-driven fan of 6000 cubic feet capacity, with 20 inches pressure, the water rate per air horsepower was 141 pounds. Some recent tests on a turbine blower of slightly larger capacity, also operating under normal gas works conditions, show an actual water rate of 76.2 pounds. In some of the later installations, higher blower pressure is being employed. Not only does the turbine efficiency in this case increase, but the fan efficiency also. In a recent test carried out on a 40-inch blower for the Brooklyn Union Gas Company, 58.5 pounds per air horsepower was obtained, with a steam pressure at the throttle of 145 pounds noncondensing.

Further tests on this equipment show a turbine water rate, when operating with 117 pounds steam and 5 pounds back pressure, of 36 pounds per brake horsepower or a Rankine cycle efficiency of 49.8 per cent. This figure is remarkably good, but it only shows what can be done in other installations if the apparatus to which it is connected can be brought up to the same standard of efficiency as can the turbine at turbine speeds.

The question of generator efficiency is no longer an unknown quantity, and guarantees made on brake horsepower can readily be verified from the electrical readings. It is unfortunate that the same cannot be said with regard to pumps and blowers, and it is often found that where a guarantee is made by the turbine builder and it apparently falls down on an actual test with a blower or pump, the pump is not operating under conditions called for in the contract and it is therefore not running at anywhere near the efficiency specified.

Comparative Performances of Turbine- and Engine-driven Pumps

With regard to the comparative performances of turbine-driven and engine-driven pumps for boiler-feed purposes, some interesting comparisons are obtainable from the tests made on board the scout cruisers "Birmingham," "Chester" and "Salem." Together with these figures are given the water rates that are obtainable from the modern turbine boiler-feed pump, showing a marked increase in efficiency in favor of the turbine-driven sets. See table on page 10.

The assumed pump efficiency equals 85 per cent. and the assumed engine efficiency equals 90 per cent. on reciprocating sets.

Napier's Formula

On the general subject of the steam consumption of small steam turbines, it is strange that Napier's simple formula* for the flow of steam through nozzles cannot be used to greater commercial advantage than it is at the present time.

$$W = \frac{P \times A}{70}$$

where

W = Weight of steam per second
P = Absolute boiler pressure
A = Area of nozzle in square inches

This well known formula has been proved so many times to be approximately correct that it is a pity that it is not more used to compute the steam consumption. The majority of small turbines now operate with a terminal pressure at the jet below 0.58 of the initial pressure, so that this formula can be readily applied to any machine and the steam consumption determined by placing a gage in the steam ring.

The maker could be called upon to give the number and the size of the jets, and in this way an instantaneous reading could be taken at any time showing the amount of steam passing at any one time. If this were done, less claims would be made that a turbine is passing a greater amount of steam than the makers claim for it. Of course, when it comes to a question of pump efficiency, this is a harder matter to determine, and it is possible that at a given water horsepower the turbine does require more steam than called for. This can only be tested out by means of a dynamometer or brake to find out where the trouble lies.

By a slight modification to the constant 10 in Napier's formula for various jets, figures can be obtained as accurate as is possible by actual measurement. In a series of tests carried out within the last few days on a certain machine, in seven readings with a ring pressure varying from 40 to 150 pounds, the minimum discrepancy between the calculated and the actual results was 1.3 per cent. and the mean over all the readings, 0.443 per cent.

The actual figures obtainable on test and those calculated are as follows:

Napier's Formula	Actual Tests	Per Cent. Variation
2028	2013.6	0.8
1264	1248.0	1.3
1935	1934.0	0.0
2625	2638.0	0.4
1905	1906.0	0.0
3047	3066.0	0.6
2272	2272.0	0.0
		3.1
	Average,	0.443

Simplicity of Design

The construction and the general design of small turbines have been so thoroughly dealt with in other papers that it is not considered necessary to go into this phase of the subject. The writer would, however, like to bring forward the fact that in small turbines, as in the larger units, the design and mechanical construction are all-important factors. What is considered good practice in the design of large turbines is, however, in many cases a mistake in small machines.

As to the details of the machine, the design should be as simple and the governor and other mechanism attached thereto as fool-proof as possible, even at the expense of efficiency if necessary. The wheels, etc., should be readily accessible, as facilities for handling such machines in the places where they are so often installed are very inadequate for this purpose, and the time allowed for the dismantling of an auxiliary is often only a few hours at the middle of the night.

That machines are designed to fulfill these requirements, and that complications in the design are unnecessary are proved by the constructions now employed. For example, it is thought by some engineers that the single governor mounted directly on the turbine shaft cannot be made sufficiently sensitive for close regulation. Figures taken from some recent government tests on Terry turbines show that this is by no means the case.

On a series of six consecutive 5-kilowatt machines for the navy, the official figures were as follows: Maximum jump of the worst machine, with full load thrown off, 3.28 per cent.; average maximum jump over the six machines, 2.61 per cent., with a mean settled variation of 1.19 per cent.

On two 85-kilowatt sets, also for the navy, the mean figure of the two machines were, maximum, 2.77; settled, 2.09.

Discussion

Mr. Orrok, of the New York Edison Co., said that in his own practice he did not often consider the water rate of a small steam turbine. He knew that under any condition of use it was better than that of the reciprocating engine which it displaced. Maintenance and upkeep were the things to look to. The Edison Co. had yet to spend its first cent for repairs on a small steam turbine, of which it has 40 in service and the oldest ones have been in operation for five years. As to the labor of running them, a man looks at them once or twice a watch, puts his hand on the bearings to see that they are not warm, and that is all the attention they get. No oiling to do, no pet-cocks to try, no wiping, no taking apart to see what is the matter with them, or picking out rust or scale, or filling oil cups, or a hundred and one other things that happen with reciprocating engines.

Mr. Cooley stated that his company had eight or ten small turbines running on pumps, a small condenser and other machines. They had had one or two bumps which were not in any way the fault of the turbine. They had a runaway on one machine, caused by a lack of a strainer on the steam pipe. A small screw came in and caught under the governor valve, and the turbine went fast enough to throw out the blades of the fan connected with it until they hooked on to the cutoff blade of the fan. The blades came out of the fan and the fan came out of its bearings. If a thing like that happened to a reciprocating engine it would be necessary to pick up the pieces in a basket. All that was necessary in this case was to replace a sprung shaft. There had been a little trouble due to the fact that the machines ran fast enough to set up a vibration on the floor, but this was remedied by placing them at proper points.

Comparison between the largest passenger locomotives built for the Pennsylvania Railroad and the oldest locomotive in America shows the progress made since the first railroad train was put into service at Bordentown, N. J., on the Camden & Amboy Railroad in 1831—eighty years ago. The oldest locomotive, "John Bull," is still intact at the National Museum in Washington. The locomotive which the Pennsylvania Railroad has adopted for heavy passenger service is of the Pacific type, and it is the most powerful passenger locomotive in use on the Pennsylvania Railroad. The locomotive and tender when loaded with coal and water weigh about 430,000 pounds. The "John Bull," loaded for operation, weighs 24,625 pounds, about one-seventeenth as much as the new engine, which has six driving wheels 80 inches in diameter. The driving wheels of the old engine are only 54 inches in diameter. The boiler of the new locomotive contains 359 tubes, each 20.9 feet long, making a total of nearly a mile and a half of 2¼-inch tubes through which the flames and heat from the firebox pass on their way to the stack. The heating surface of the tubes is 4420.6 square feet and, in addition, the firebox has a heating surface of 199.3 square feet. This space is heated to a high temperature to convert the water in the boiler to steam at a pressure of 205 pounds per square inch. The tubes in the "John Bull" are 7½ feet long, and the tube-heating surface is only 213 square feet.

WATER RATES OF SMALL TURBINES

	Steam Pressure, Pounds	Back Pressure, Pounds	G.P.M.	Head in Feet	W.H.P. Water Rate	Turbine, Pounds	Per Cent. Improvement
"Birmingham	183	6	329	488	83.0	61.8	25.5
"Salem"	203	6	193	690	91.8	61.2	33.6
"Chester	187	6.7	219	610	101.0	64.0	34.6
					275.8	187.0	93.7
Average					91.9	62.4	31.2

Large Turbine at Providence

By John R. Hess

Description of a new 15,000-kw. turbo-generator installed at the Manchester St. station of the Rhode Island Co.

The new 15,000-kw. turbo-generator built by the General Electric Co. for the Rhode Island Co., of Providence, R. I., was put in regular service at the Manchester Street power station on Sunday, Nov. 26. It supersedes the 1500-kw. horizontal reciprocating engine-driven unit and occupies less than one-half the ground area required for the latter. The weight of the new machine and auxiliaries is approximately 500 tons and its cost, including the switchboard, three rotary converters, condensers, etc., was $340,000. It is of the vertical, four-stage Curtis type designed to operate at 750 revolutions with 150 lb. steam pressure and 75 deg. superheat.

The generator is of the three-phase, 25-cycle, 11,000-volt type. The rating is based upon a rise of 75 deg. C. with a room temperature not exceeding 25 deg. The speed variation is not to exceed 2 per cent. The steam-consumption guarantee calls for an economy of 17 lb. at 7500 kw. and 16.2 lb. at 15,000 kw. when operating with a vacuum of 28 in. However, as it is the expectation of the company to operate this turbine with 150 deg. superheat and a pressure of 160 lb. steam pressure, it is presumed that at 10,000 kw. (the average output) the steam consumption will approximate 15.2 lb. of steam per kilowatt-hour.

Owing to the capacity of this machine and the characteristic of the load curve, it is expected that it can take care of the entire output of the plant without assistance from the other units during 300 days of the year.

The condenser is of the twin-suspended LeBlanc type, having one exhaust head connected to the turbine and is capable of handling 8,000,000 lb. of cooling water per hour. One peculiarity of this condenser is that it is supported upon a steel column, the top of which is on a line with the base of the turbine. There is a clear space under the condenser of approximately 12 in., which allows the expansion to take place downward should the vacuum be lost and the temperatures rise accordingly; in this way there is no tendency to throw the turbine shaft out of position.

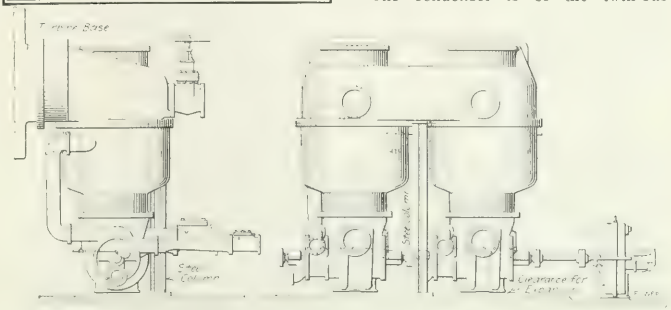


FIG. 2. SHOWING METHOD OF SUSPENDING CONDENSER

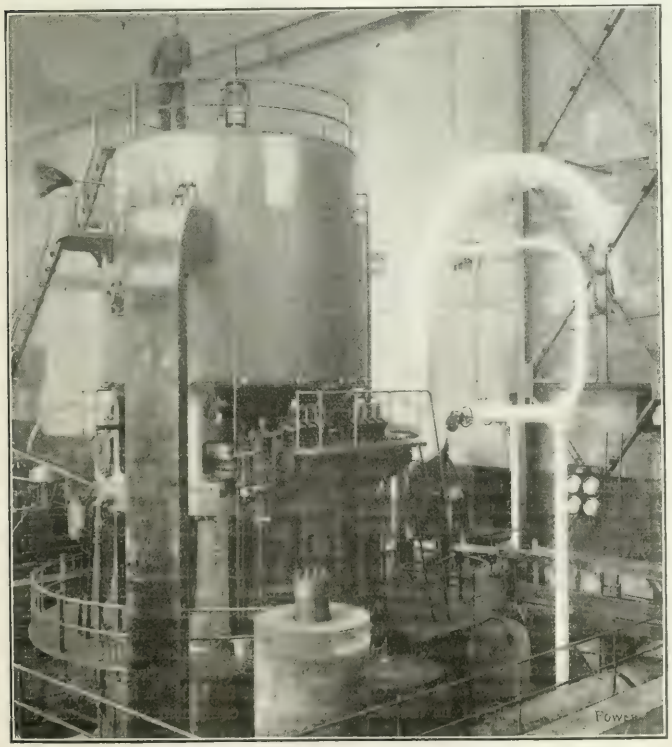


FIG. 1. GENERAL VIEW OF 15,000-KW. TURBINE

Before selecting this type of unit, various studies were made of the low-pressure turbine, and it was found that as the load upon the station increases, the steam-consumption curve of the high-pressure turbine, as adopted, would be practically the same as if low-pressure turbines had been employed. Therefore, the overall economy of the station will be less with the high-pressure turbine than if low-pressure turbines had been specified. The arrangement also gives greater simplicity in the installation and operation over any low-pressure turbine installation.

The company now has 12 units with a capacity of 53,000 horsepower.

The English bankers, Lazard Frères, have invested $3,000,000 in Vancouver Island coal properties. The investment will be largely devoted to exploration work and for installing haulage power, made possible by hydro-electric plants.

Coal Delivery, Candler B'ld'g, Atlanta

By R. C. Turner

By purchasing its own coal-storage yard and substituting an automobile truck for the mule teams formerly used in carting, the company has effected a considerable saving.

Considerable space has been devoted by the technical press to describing coal and ash handling in the boiler rooms of power plants, but very little has been said of cutting the cost of delivery to the isolated plants located in the business districts of cities, a mile or more from the railroad; here the problem of cartage is very important. At the plant of the Candler Building, in Atlanta, Ga., this problem has been solved very satisfactorily. It is one of the largest isolated stations in the South, using on an average 20 tons of coal per day, although during the winter months as much as 30 tons are often used in a single day. In order to get a satisfactory price on the coal the management found it necessary to take four cars per week throughout the year.

Owing to the slow placing of the coal cars in the yards by the railroad company, which would leave them first in one yard a mile from the plant and next in a different yard possibly two miles or more from the building, great delay was caused in getting the coal for the building.

After spending considerable money for extra teams and demurrage, the owners of the building decided to build their own yard and do their own carting. At this yard, which was 1½ miles from the building, a sidetrack 350 ft. in length comes in from the railroad. When brought in, the cars are immediately switched onto the trestle and the coal is dumped into the bunkers 15 ft. below, the average time required to empty a car being 10 minutes. As soon as the cars are emptied the railroad company is notified, and they are hauled away. Demurrage is now a thing of the past.

The coal is carted to the plant in a five-ton motor truck, the illustration showing it discharging coal to the boiler room, 30 ft. below the street level. Four loads of five tons each are delivered to the building per day and two loads of cinders and refuse are hauled away and delivered to the purchasers of this waste material. On Saturdays, 40 tons, or eight loads, are delivered, thus avoiding a Sunday delivery.

Before adopting the motor truck two double teams and four men were required for this service. A comparison of the two outfits is as follows:

Old Service—Investment		
Two wagons	$400.00	
Four mules at $225	900.00	
Stables	600.00	
Four sets of harness	100.00	$2,000.00
Operating Expenses—One day		
Four men, labor	$6.50	
Feed	1.60	
Depreciation, wagons and stock	0.70	8.80
New Service—Investment		
One motor truck	$3,800.00	
Shed at coalyard for housing truck	200.00	4,000.00
Operating Expenses per Day New Service		
Two men, labor	$2.75	
Nine gallons of gasoline, at 11 cents	0.99	
Oil and grease	0.20	
Depreciation	1.00	$4.94

The investment at the coalyards is $1200. It is estimated by the managers of the building that the saving in demurrage charges alone will pay 8 per cent. on the total investment. As coal is the most expensive item in the operation of any power plant, any improvement that will lessen the cost is welcomed by the engineer.

When the subject of buying a motor truck was considered various types were investigated before placing the order for the machine. For a while the electric truck was seriously considered, but owing to the excessive weight of batteries and the amount of dust and dirt that would be encountered in the service it was decided that an electric truck would not be as efficient as the gasoline. The truck selected is a four-cylinder, water-cooled machine rated at 70 hp. After being in service for several months the only repairs that have been made or needed were new linings for the brake bands.

TRUCK DISCHARGING COAL

Seneca River Boiler Tube Blowout

In the Nov. 28 issue of POWER there was reported a fatal accident due to the blowout of a tube in a 400-hp. Babcock & Wilcox boiler used on a canal dredge in Seneca County. Since then there have been two coroner's hearings for the purpose of fixing the responsibility of the accident and there is likelihood of several more. From an engineering standpoint, however, the direct cause of the accident has been fairly well established, details only being necessary to make it complete. It was shown that the failure was due either to defective material, to material weakened by pitting or corrosion, or to material weakened by overheating, there being nothing to show the existence of an excessive pressure.

The following pertinent facts have been established at the coroner's hearings:

The insurance-company inspector who passed upon the boilers last September made a thorough examination of the port boiler only, the one on the starboard side being in operation at the time of his inspection. (The starboard boiler was the one that failed.) In his opinion, the boilers and equipment were among the best in use on the barge-canal work. This inspector is expected to testify at a later hearing.

The safety valve had blown properly several times the day before the accident, and was set at about 200 pounds.

Leaky tubes had been reported in the port boiler shortly before the accident, and it was planned to replace 12 old tubes in both boilers with new ones in a few days. No evidence was brought out to show that the starboard boiler was under suspicion, nor was it declared why it was decided to replace any of the tubes. The tubes of the starboard boiler were, so far as was known, the ones furnished originally by the makers when the boiler was installed three years ago.

After the accident, the broken tube and eight others were replaced with new ones. According to the master mechanic of the dredge, the eight tubes removed showed bulges indicating overheating.

Upon first thought it seems likely that the disaster was due to low water, the steam that did the damage coming from the port boiler. In this case mostly steam would have escaped into the boiler room. It can be shown by computation that the heat stored in the normal contents of such a boiler under the existing conditions is sufficient to evaporate about one-eighth of its weight. This type of boiler of a size warranting a 400-hp. rating would contain normally about 330 cu.ft. of water. A blowout in one of the lowest row of tubes (which was where the trouble occurred) would therefore allow the conversion of about 40 cu.ft. of water into steam at atmospheric pressure, the greater part of the balance of the boiler's contents emitting as water at 212 deg. Obviously, then, if normal water level had existed just before the accident, a considerable amount of water would have appeared in the boiler room after it, and the lack of this would show conclusively that the failure was due to low water at the time.

The condition of the boiler room regarding wetness was investigated at the last coroner's hearing, and the testimony showed that its floor was "covered with puddles." Although this does not absolutely dispense with the low-water theory, it is strongly against it. Furthermore, if the boiler had been operating at its rated capacity, it would have taken between 1 and 1½ hours to uncover the upper ends of the lowest row of tubes, assuming the feed water to have been entirely shut off. It seems hardly likely that such a condition should have obtained for so long a time and happen coincidently with a false water level. It was testified that the water column, shortly before, showed 4 in. of water.

It seems reasonable, therefore, to look elsewhere for the cause of the overheating. If it happened just before rupturing, it may have been due to impurities such as mud sufficient to impede the circulation. But an elaborate filtration system was used to keep the river mud out of the feed water, and, although this does not make an accumulation of it in the boiler impossible, it does render improbable that hypothesis. This leads to the conclusion that the overheating was done some time prior to the accident, the metal being bulged and weakened only at that time, and giving away later under the caprice of circumstance. On the other hand, it is odd that a bulge which must have been in plain view on the tube that failed, not to speak of the eight other defective tubes, should have escaped observation for any length of time. The fact that there were leaky tubes in either boiler seems to be aside from the point, except in that such leaks may have drawn attention away from the object of real suspicion.

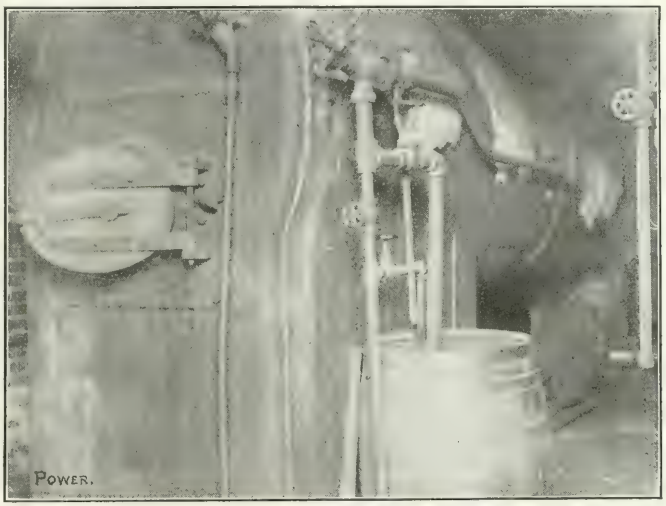
A few general remarks regarding boiler-explosion inquiries may not be amiss. It seems improper that such an investigation should be conducted by lawyers who have no knowledge of the conditions bearing upon such an accident and who cloud the issue by magnifying trivialities. In this particular case, local sympathy for the victims and prejudice against the barge-canal construction contribute to obscure the facts. That there were leaky tubes, to the lay mind, shows conclusively that the boilers were in seriously bad condition, and if an accident accompanies that condition, by the same false reasoning, this incontrovertibly links the cause to its effect. It seems that a board of expert and impartial engineers should be employed to pass upon the causes of boiler explosions. Investigations would then be carried out along logical lines and only factors pertinent to the case would be considered. The legal responsibility could then be fixed by their findings.

Taking Chances with Old Boilers

By Charles F. Adams

Every year in the heating season there appear in the newspapers and engineering periodicals sundry accounts of failures of old boilers used only during this season, for heating, ice harvesting, etc.

An example of a "chance" which, if an accident occurs, will be up to somebody to explain, can be seen in the conditions under which two boilers, used to furnish heat for passenger cars in a local railroad storage yard, are operated. One of these boilers is said to be more than forty years old, and was described in an article entitled "Old Boilers in Massachusetts," appearing in the Dec. 6, 1910, issue of Power in which it was said to be the oldest boiler in high-pressure service in the state, a claim which has not as yet been questioned.



View of One of the Old Boilers

It would be supposed that the age of this boiler would furnish a sufficient incentive for maintaining a close observation over it; apparently such is not the case. The last inspection was made July 30, 1910, and, although the plant was idle during the past summer, and the records must show that the time of inspection had passed, no objection was made to the boilers being put into service this season. That the boilers have not received the benefit of even a change of water since the last season is manifest, as both blowoff cocks are plugged with pipe plugs, which are corroded and rusted, showing that they have not been opened for a long period. Both boilers

present a much patched and dilapidated appearance, as may be seen from the accompanying illustration.

The following data are taken from the inspection certificate posted on the wall:

No. 1. Age, unknown; builder, unknown; length, 16 ft.; tensile strength, 45,000 lb. per square inch; thickness of shell plates, 3/8 in.; type of joint, single-riveted lap; strength of joint, 49 per cent.; type of boiler, locomotive; diameter of shell, 48 in.; thickness of head, 1/2 in.; pressure allowed, 52 pounds.

No. 2 is described as: Age, 26 years; builder, unknown; length, 16 ft.; tensile strength, 45,000 lb. per square inch; type of joint, double-riveted lap; strength of joint, 62 per cent.; thickness of head, 7/16 in.; pressure allowed, 52 pounds.

Caught in the Economizer Flue

By E. R. Emerson

"Talking about frights, well, I don't think anyone will care to have a fright and shock similar to the one I had some 25 years ago," began Bill, the engineer. So we all drew a little closer; we knew Bill could tell a good tale when he got started.

"I'm not likely to forget it in a hurry, either. You see my hair," said Bill, lifting his cap. We all noticed how snow white it was, but until now had never thought anything about it as Bill looked over 50 years of age and white hair is not uncommon at that time of life. "My hair was as white as it is now three days after the affair I am going to tell you about, and I was then only 23 years of age.

"Well, to go on with my story, our chief engineer had a habit of putting locks and chains on everything that he thought might be a source of danger; if a boiler was shut down for cleaning he would have the main stop valve and the blowoff fastened with a padlock and chain, until all the work was done, and then he would unlock them, keeping the keys to himself.

"There were six boilers in our plant, connected to an economizer, with a direct flue, so as to divert the gases straight to the stack instead of through the economizer flue when it was desired to clean out the latter flue.

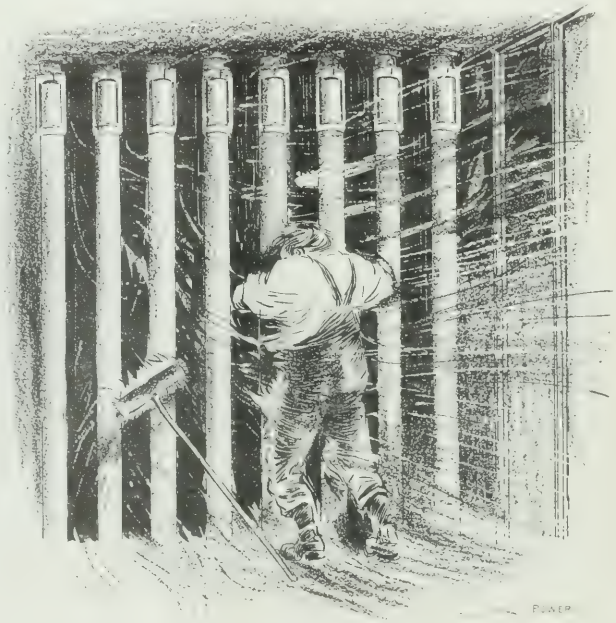
"Two days before we were given orders to clean out this flue, the chief had taken the usual precaution to lock both inlet and outlet doors with a padlock and chain on each, leaving everything secure and ready for the entrance of the cleaners. As soon as the flue was cool enough, I was told to clean out one of the center nests of tubes. I found it to be hotter work than I had anticipated as the feed water from the exhaust-feed heater was still flowing through the economizer tubes, and every time I had my hands on them to steady myself I was forcibly reminded to take them off again.

"All went well until I started to clean down the tubes next to the outlet door. This door, of course, was shut tight and was supposed to be securely padlocked on the outside. When the economizer was in commission this door led direct into the fan chamber and then to the stack. I had just started to clean down the first row of tubes on the fan side from the door, when suddenly there was a tremendous roar and I felt myself lifted bodily from the floor of the chamber. Next I was jammed tight against the hot tubes, but for the presence of which the fierce draft would have carried me through the door; hot ashes burned into my skin and flesh and my clothes were soon in flames. Instinctively I clutched the tubes, but how they scorched me! At last I felt my strength giving way, my eyes were filled with fiery dust and every breath I took was like molten metal filling my throat and lungs. I had a vague idea of a thousand demons prodding me with pitchforks; then I must have swooned, for I imagined myself being drawn through the fans and sailing all serenely up the smokestack, wondering what I should do when I got to the top.

"When I came to they had cut off my burning clothes, and were dabbing oil all over me. Oh, how my eyes and throat smarted!

"However, after a few weeks in the hospital I was about again and, with the exception of my hair, which was then just as white as you see it now, I had no disfigurement whatever.

"It was while convalescent that I learned how the affair happened. It seems that it was due to the smartness of an 18-year-old youth that I owe my life. He was working at the other end of the economizer close to the door leading outside and, hearing my shout, rushed outside, jumped up onto the top of the economizer, colliding with the chief in his hurry, and rushed to the outlet-door handle. He swung it around with such force that he nearly broke the door.



Suddenly There Was a Tremendous Roar and I Was Jammed against the Hot Tubes

"By this time the chief had reached his side and, looking round, he was astonished to discover a crowbar lying there and the chain broken into two pieces. Telling the boy to stick to the handle, he soon had me brought out.

"When all was over, he went through to the engine room and was just about to hold an inquiry in an effort to find the fool who had done the mischief, when his eye fell on the log sheet. There in bold characters he read in the 'remarks' column:

" 'Noticed economizer handle out of place at 10:39 a.m.; straightened it with a bar; all well.'

"I don't know exactly what the chief's remarks were to the new switchman, but I rather think they were hot ones."

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

INCANDESCENT LAMPS—THE VAPOR TUBE LAMP

1175. *Are there any other forms of incandescent lamp?*

Yes; there is one more general class known as vapor-tube lamps. Fig. 393 shows the Cooper Hewitt direct-current mercury vapor lamp, which is one of this class.

1176. *Describe the construction of the mercury vapor lamp.*

It comprises a clear glass tube *N* about an inch in diameter and from 20 to 50 in. long, in which is a small quantity of mercury. This tube, like the filament-lamp bulb, has the air pumped out and is sealed. The mercury is held in the large bulb *A* at the left end of the tube and serves as the negative electrode. The positive electrode is a small iron cup *C* at the right end of the tube. Platinum wires sealed in the glass carry the current to the electrodes. The current passing from one electrode to the other vaporizes some of the mercury, and it is this vapor which emits the light. The inner surface of the reflector *S* is finished in smooth, white porcelain.

The part *M*, shown separately in Fig. 394, contains two inductions coils *N* and *L*, and an adjuster resistance *B* by means of which the current is regulated according to the voltage of the supply. For lamps connected in series, a shunt resistance *T* and a cutout *O* are also included. The binding posts *X* and *Y* are for the leads to the tube, and the binding posts *P* and *F* are for connection to the supply wires.

1177. *How is this lamp lighted?*

By closing the switch controlling the circuit and then pulling down the chain *R*, Fig. 393, attached to the left end of the holder. This pours the mercury out of the bulb along the tube. The stream of mercury is thus momentarily made to connect the electrodes and the breaking of this continuous stream lights the lamp.

1178. *Is no provision made for automatically relighting this lamp in case of an interruption of the current supply?*

Provision for automatic relighting is made only in the automatic type of Cooper Hewitt direct-current lamp shown in Fig. 395, the tilting being here accomplished by means of an electromagnet in the part *D*. When the circuit is closed through this lamp the current flows through the electromagnet which tilts the tube for lighting. This automatic tilting is desirable in places where it would be difficult to reach the chain by hand; and it also insures the relighting of the lamp in case there is a momentary interruption of the current supply.

1179. *In the lamp shown in Fig. 395, are the two tubes connected in series or parallel?*

In series.

1180. *What is the rated candlepower and what the efficiency of the lamp shown in Fig. 393?*

The candlepower is 300 and the efficiency is 0.64 of a watt per candlepower.

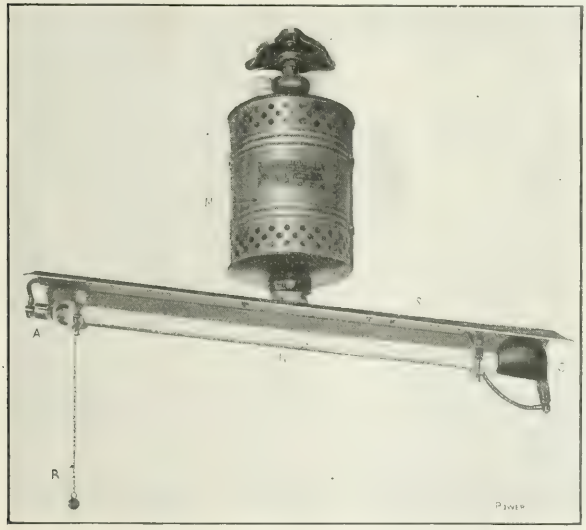


FIG. 393. COOPER HEWITT MERCURY VAPOR LAMP

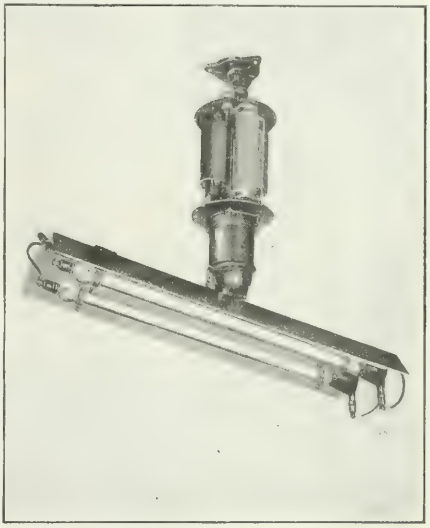


FIG. 395. DOUBLE-TUBE MERCURY VAPOR LAMP

1181. *Is the mercury vapor lamp made for alternating-current circuits?*

Yes. The mercury vapor lamp for alternating-current circuits differs from the direct-current lamp somewhat. The principal difference is in the auxiliary part, which contains a transformer for supplying the proper voltage to the tube electrodes, two choke coils, a shifter consisting of a small glass vessel fitted with two electrodes and containing a small quantity of mercury for lighting the tube, and the shifter resistance.

1182. *How often must the glass of a mercury vapor lamp be renewed?*

After about 3750 hours of service.

1183. *What kind of light does the lamp give?*

A greenish-colored light which has great penetrating power. It enables printed matter to be read with unusual ease and brings out with great clearness the fine markings on steel rules, and small scratches and defects on other bright metals.

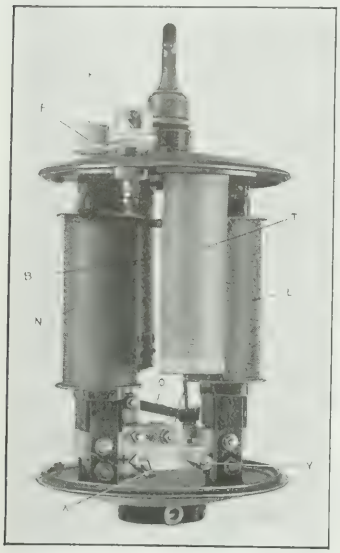


FIG. 394. MECHANISM OF MERCURY VAPOR LAMP

1184. *Is there any other form of vapor-tube lamp?*

Yes. The Moore lamp shown in Fig. 396 is classed as a vapor lamp because light is produced in it by passing an alternating current through carbon dioxide gas contained in a glass tube from which the air has been pumped out.

1185. *What kind of light is given by the Moore lamp?*

A clear, white light of about 200 candlepower, possessing practically the same color values as natural daylight. The Moore light is therefore particularly advantageous in matching colors at night or during dark days.

FIG. 397. STRAIGHT-LINE MOORE TUBE

1186. *Does the carbon dioxide gas become exhausted?*

It does, and for this reason there is a compartment behind the glass tube *G*, Fig. 396, containing the gas which is fed automatically by means of an electric valve into the tube as it is needed. The carbon dioxide in the compartment has to be renewed after about 1000 hours of service. On account of a deposit gradusally forming in the tube *G*, the tube also has to be renewed after 4000 or 5000 hours of service.

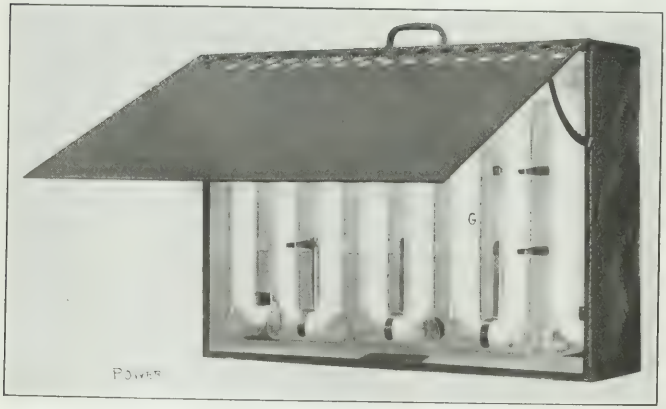


FIG. 396. MOORE VAPOR-TUBE GLOW LAMP

1187. *How much current does the 200-candlepower Moore lamp require?*

At 110 volts it requires 23 amperes; at 220 volts, 11½ amperes.

1188. *Is this lamp made in any other form than shown in Fig. 396?*

Yes; for the general illumination of large areas the glass tube, instead of being arranged in gridiron fashion, as in Fig. 396, is straight and intended to be hung from the ceiling, as in Fig. 397, or made a part of the cornice. In this form it gives "line" instead of "spot" lighting. If nitrogen gas instead of carbon dioxide gas be used in the tube, a yellow light can be produced instead of a white light.

The Wrong Bearing Heats

BY J. E. LATTA

The necessity of the correct alignment of the bearings on any machine having more than two bearings on the same shaft is too well understood to need discussion now, and the evils of extremely tight belts are also very generally appreciated. However, some recent troubles with bearings, which seemed to be due to the belts having to be run too tight, I have never fully understood. There was a large belted alternating-current dynamo, of the revolving-field type, with a pulley 24 in. in diameter, which was driven by an engine having a belt-wheel 12 ft. in diameter, the distance between the center of the dynamo shaft and that of the engine being only 23 ft. Naturally with such an extreme layout as this, the belt had to be very tight in order to prevent it from slipping badly. The dynamo bearing next to the belt never showed any signs of heating, but the other one always became very hot on long runs.

The heating invariably began at the bottom and spread slowly throughout the bearing. We tried all the usual remedies for the trouble, except that of moving the machine farther away and using a longer belt, such a change as this being impossible on account of the lack of room. Half a dozen different grades of oil having been tried had the usual applications of sulphur, graphite, sapolio, etc., having proved ineffective, we tried raising the shaft of the dynamo slightly by putting paper liners under the bearing, thinking that the resulting lengthening of the lower portion of the airgap and the consequent lessening of the downward component of the magnetic pull on the revolving field might relieve the trouble. But the heating persisted as bad as ever. During long runs in hot weather we were forced to apply ice to the bearing in order to keep the generator going.

The provisions for driving a 50-kw. alternator in this plant were about the same as those just described, and on a

24-hour run the bearings of this machine behaved very much like those of the larger generator. It is not at all clear to me why it was always the bearing opposite the belt which got hot, nor why the heating always began at the bottom of the bearing.

We never allowed either one of the bearings mentioned to get hot enough to require much scraping. In this connection, it may be appropriately remarked that many engineers are inclined to use the babbitt scraper more than is necessary or desirable. However, I will appreciate any suggestions that other readers may offer as to the reason why the heating occurred in the bearings not subjected to belt pull.

An Electrically Driven Blowing Engine

By S. R. Stone

An interesting example of the adaptation of electric drive to the modern high-duty blowing engine is afforded by an installation at the Mammoth smelter, near Kennett, Calif., of the United States Smelting, Refining & Mining Co. Here the forward end of a standard duplex machine, with cylinders 44 and 44 by 48 in., is driven by ropes from a 75-hp. 2000-volt induction motor. The blower runs at 75 r.p.m. and supplies, at 15 lb. pressure, 13,000 cu.ft. of free air per minute for the blast for copper converters. Regulation of the supply is effected by automatic throttling of the air inlets. This permits the motor to run constantly at maximum speed, which benefits the power factor of the system.

The use of a motor instead of a steam engine was brought about by the fact that the company has no boiler plant but operates its mines, smelter and trams by means of electric power obtained from the hydro-electric development of the Northern California Power Co. Other conditions being equal, a direct-connected blowing engine would perform the same service on not more than 700 b.hp. and with considerably greater efficiency.

LETTERS

Mr. Hawkins' Compressor Motor

Referring to the letter of J. C. Hawkins, in the Oct. 31 issue of Power, regarding the sparking of a 7½-hp. shunt-wound motor, I would say that sparking, from any cause, would heat up the whole motor to an extent depending on the amount of sparking. In all probability the damp condition surrounding the running of this motor has a good deal to do with it. As to the question of whether a compound-wound motor would give better results, while I do not know all the conditions under which this motor is running, before condemning the shunt-wound motor I would suggest to Mr. Hawkins to try the plan of soaking the carbon brushes in machine oil for 24 hours, then wiping clean and allowing them to dry for six or seven days. With a narrow, sharp chisel, cut the mica between the commutator segments down ⅛ of an inch, as I think his repeated sandpapering of the commutator has left the mica high, which does not allow the brushes to make good contact on the commutator surface. Then with the mica cut down and the commutator clean, put on the oil-soaked brushes. While this may not stop the sparking entirely, I think it will give a great degree of relief.

Herbert Hill.

Middle Falls, N. Y.

[Since the above was received we have been informed by Mr. Hawkins that a compound-wound motor has been put in in the place of the old one and it runs without giving any trouble. The difficulty would seem, therefore, to have been that the current rushes due to the compressor strokes went beyond the sparkless limit of the constant-field (shunt-wound) machine.—Editor.]

In regard to the trouble with our shunt-wound motor driving an ammonia compressor, I wish to comment on the several answers to my inquiry and state how the trouble was stopped.

The sparking occurred at all times, but it was worse when making the compression stroke, although an ammeter in the line showed only about 3 amperes fluctuation, the range being from 26 to 29 amperes. The motor is rated at 7½ hp. at 220 volts and stamped for 30 amperes full-load current. The voltage at the machine was 222.

In reply to my original letter, Mr. Scott said that a compound-wound motor would not give better service on this intermittent load than a shunt-wound motor, and stated cases that had been cured of a similar trouble by building a higher foundation to raise the motor off the floor and putting in a larger motor. Mr. Jackson gave several conditions, any one of which might cause similar trouble, but neither he nor Mr. White (in the same issue) says anything regarding the compound-wound motor. Mr. Jackson is correct in that the motor did run very hot, and in a very short time after cleaning the commutator it became blackened and scored, as I stated in my previous letter.

Perhaps Mr. Jackson's theory in regard to the field strength of the different poles and improper spacing of the brushes is the correct one, but the motor was new and not only our electricians but an expert from the makers did everything they could think of to make the motor run satisfactorily, as the acceptance of the whole plant was being held up on account of the motor.

About the middle of October the shunt-wound motor was taken out and a 7½-hp. compound-wound motor was placed on the same foundation. During the two months that it has been running it has shown no signs of sparking, it runs quietly and cool, and the commutator is smooth and has been cleaned with No. 00 sandpaper only once during this time.

My opinion is, as it was at the time of my first letter, that as the load ranges from practically no load on the suction stroke to full load on the compression stroke, nothing but a compound-wound or an interpolar motor should have been installed in the first place.

This view is based on the results of several years of experience in a plant where there were some 75 motors, many of which were used on punch and shear machines, air compressors, cold-pipe saws and other similar machinery. All of the motors were compound wound and some of them had displaced shunt-wound motors. Furthermore, I have received a letter from the General Electric Co., stating that a compound-wound motor, preferably of the interpolar type, should have been used.

I thank those who replied to my letter of Oct. 31; the information will no doubt be of help at some future time.

J. C. Hawkins.

Hyattsville, Md.

What Causes the Exciter to Rattle?

We have a direct-connected alternator and a belted exciter. At rated speed and up to half load it runs perfectly. Any more load causes it to rattle or vibrate. The vibrations do not coincide with the number of revolutions per minute.

The exciter has been examined and each part tested by four engineers. There seems to be nothing loose; the armature is in balance, but the bearings are slightly worn now as the machine has been running about six months.

It has always given the same trouble. At first the pulley was out of balance, but that has been corrected with no benefit. I have tried running it without the pulley, as a motor, but it still rattles. Can anyone tell why?

W. M. McGinnitie.

Haddock, Wash.

Dyeing Incandescent Lamp Bulbs

Will some one of the readers of Power tell me what process to use for coloring incandescent-lamp bulbs red?

Harry L. Seifts.

Philmont, N. Y.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Smith Recording Gas Calorimeter

The accompanying illustrations represent the two elements of an equipment devised by H. F. Smith, the well known producer engineer, for continuously measuring and recording the heat value of gases. The equipment comprises a sampling pump, Fig. 1, and a recording calorimeter, Fig. 2. The sampling pump consists of a rotary air pump and a reciprocating gas pump having a common shaft driven by an electric motor through single-reduction spur gears. The two pumps deliver air and gas to the calorimeter at a constant volume ratio, the inequalities of pressure in the gas-pump

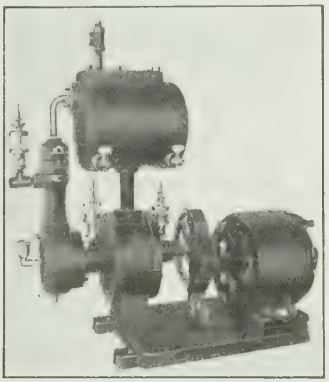


FIG. 1. SAMPLING PUMP

cylinder being smoothed out by the little holder shown above the pump. The air pump is used merely to displace the air required for the calorimeter, and since the air is delivered under practically no pressure, there is very little if any slip.

The gas pump is of the single-valve type, the discharge valve being a poppet valve covering the entire area of the cylinder. The inlet is a port entirely surrounding the cylinder, and it is uncovered by the piston at the downward end of the stroke. The piston is six diameters long, and is ground to a very close fit in the cylinder. Since the piston over-travels at both ends, the volume of gas displaced at each stroke is the volume contained between the upper edge of the inlet port and the discharge valve, at the time the piston covers the inlet port on its up stroke. Consequently, there is no variation in the amount of gas delivered, due to variations in the length of stroke. The pumps are calibrated so as to deliver one volume of gas and 29 volumes of air; in practice this calibration has been found to be quite permanent. The gas and the air from the sampling pump are conveyed through separate pipes to the calorimeter proper.

The calorimeter housing consists of a labyrinth of thin steel tubes, the outer one forming the frame of the instrument. The air supplied to the calorimeter first enters the space between the outer tube and the next one within, and passes down through this space, through a communicating passage at the bottom into the space between the second and third tubes, passing upward through the second and third, and at the top into the space between the third and fourth, and so on to the center. The central tube constitutes a combustion space, the gas being led directly into this space through a burner tube in the bottom of the instrument. The gas burns directly in and with the air supplied by the sampling pump, and the heat generated by combustion is employed in raising the temperature of this air; the rise in the temperature of the air is taken as the direct measure of the heat value of the gas.

The rise in temperature is measured by an expansion couple. The low-temperature or zero member of this couple is the outside tube of the set, previously mentioned, which constitutes the frame of the instrument. This tube is exposed on its outer surface to the surrounding atmosphere and on its inner surface to atmospheric air that has been delivered by the pump. The high-temperature member of the couple consists of a steel tape attached at its lower end to a bearing pin which in turn is supported by the outside steel tube or low-temperature member of the couple. The other end of this tape is connected to a system of multiplying levers which record the difference in length, and consequently the difference in temperature between these two members. By making the high-temperature member thin, the instrument is made very sensitive to small variations in temperature. In practice a double steel tape 0.015 of an inch thick is found to give excellent satisfaction. Owing to the fact that this tape is always at a high temperature no corrosion is experienced, even with gases very high in sulphur.

With the air-to-gas ratio of 29, a temperature difference of 1 deg. C. is about equivalent to 1 B.t.u. per cubic foot of gas under standard conditions. The temperature difference in producer gas of 150 B.t.u. would therefore be approximately 150 deg. C. The products of combustion being discharged at temperature above the point of saturation, the readings are always in terms of net or low heat value.

It is not immediately apparent why this instrument will give readings that are automatically corrected to the accepted standard of temperature and barometer, but a brief consideration will suffice to show why this is. It should be observed, to begin with, that changes in either temperature or barometer change the density of the gas; both of these

FIG. 2. RECORDING CALORIMETER

factors may therefore be considered at the same time. Assuming the instrument to be operating under standard conditions, on producer gas of about 150 B.t.u., the sampling pump will deliver in a certain time 1 cu.ft. of standard gas and 29 cu.ft. of standard air. The combustion of the gas will cause a temperature rise of approximately 150 deg. C. In other words, 1 cu.ft. of gas will heat 30 cu.ft. of mixture 150 deg. C.

Now assume that, owing to changes in barometer or temperature or both, the specific volume of the gas is double its original bulk. The gas, however, is delivered to the sampling pump under the same conditions of pressure and temperature as the air; that is, at atmospheric temperature and at atmospheric pressure. If, therefore, the gas is delivered at one-half normal density, the air will also reach the sampling pump at one-half its normal density, and in the same period of time as before, the sampling pump will deliver what is equivalent to ½ cu.ft. of standard gas and 14½ cu.ft. of standard air. It is very evident, however, that ½ cu.ft. of gas will heat 15 cu.ft. of mixture through exactly the same temperature range as 1 cu.ft. of gas will heat 30 cu.ft. of mixture. Therefore, under these new conditions, the temperature difference produced in the calorimeter will be exactly the same as though the instrument were operating under standard conditions. The only requisite is that the gas and the air should be delivered to the sampling pump at the same temperature and pressure, and this condition being met, the readings of the instrument will always be in terms of standard gas at sea level, theoretically.

Of course, in practice this is not strictly true. The radiation losses from the instrument would be proportionally greater with the smaller number of actual heat units per minute liberated in the instrument, but over any ordinary range of conditions the error is not of sufficient magnitude to be of any importance. For example, a change in conditions that is equivalent to a change in altitude from sea level to 6000 ft. elevation will cause about 1½ per cent. deviation from actual sea-level readings. It would no doubt be possible to construct an instrument on this principle that would compensate for all variation in temperature and pressure, but this refinement has not been attempted on this instrument because Mr. Smith did not consider such extreme accuracy necessary in producer practice.

It has been suggested that the condition of the air entering the calorimeter with respect to its content of water vapor would have an appreciable influence on the readings of the instrument, owing to the fact that water vapor has a specific heat of about 0.48, whereas the specific heat of air is only about 0.24. It should be observed, however, that the specific heat is calculated on the basis of unit weight, and that the specific gravity of steam is only about one-half that of air; therefore, the heat-absorbing capacity of water vapor per unit volume is almost exactly equal to that of air. Consequently, except in instances where the greatest possible refinement is required, the percentage of water vapor is of no consequence. With respect to radiation losses, it is explained that the labyrinth construction of the calorimeter reduces these to a very small amount.

The advantages of the instrument may be briefly summed up as follows: It is a commercial power-plant appliance that will run continuously with practically no attention. Inspection of records made under different conditions soon enables the producer fireman to determine the best available fuels, the best operating conditions and, above all things, gives an immediate solution of that perplexing question of responsibility in gas-power plants as to whether trouble lies in the gas producer or the gas engine. Mr. Smith informs us that it has been found possible by the use of this instrument to control the quality of gas made from bituminous coal so closely that a variation of not more than 10 B.t.u. per cubic foot will occur.

The instrument is manufactured by the Lexington Instrument Works, Lexington, Ohio.

The Cost of Oil Power

At the New Haven meeting of the American Society of Mechanical Engineers, a paper on the above subject was read by Messrs. F. P. Pfleghar and E. H. Lockwood. An abstract of this paper was published in POWER for Dec. 5.

In the discussion which followed the reading of the paper, Mr. Krah, superintendent of the plant containing the oil engine which was the subject of the tests reported in the paper, said that his experience with the engine had been that it gave more trouble than a steam engine, because of the high temperatures involved, and the cost of repairs is high.

The exhaust valve ought to be taken apart [?] every week and cleaned, which takes a man four or five hours. The engine has never delivered its full rated horsepower, he claimed, because the fuel oil is not thoroughly vaporized, and cleaning out the carbon deposit due to this fact takes a long time.

During the summer, he said, the oil engine was very economical but in winter he thought it cheaper to run the steam engine because of the need for heat, which is supplied by exhaust steam. Moreover, the oil engine was not considered sufficiently reliable to justify taking out the steam plant.

The paper by Messrs. Pfleghar and Lockwood, abstracted in the Dec. 5 number of POWER, affords a very striking comparison of oil-engine and steam-engine costs in actual operation. Those who heard the discussion of this paper, however, will recall that the statement was made by the superintendent of the plant that the oil engine is, unfortunately, still unreliable; owing to serious interruptions to production, the steam auxiliary plant is still maintained. In view of the necessity of this form of insurance, it does not seem unjust to charge the fixed expense of the steam plant against the oil-engine account.

It is therefore pertinent to make further comparison of power costs and I therefore respectfully request that you publish this letter and the following table in which the cost of central-station power is based on existing rates in New Haven:

	Central Station	Oil Engine	Steam Engine
Operating costs per hp per year	$53.15	$32.30	$53.00
Fixed charge per hp per year...	1.35	19.45	8.90
Total cost per hp. per year.....	$54.50	$51.75	$61.90

A slight increase in power used would reduce the operating cost per horsepower-year to $50 for electrical energy. Adding the fixed charge, it is apparent that the electrical service is just as cheap as this oil engine has proved to be. There is good reason to expect that the use of say four groups, each driven by a 25-hp. motor, will effect some saving in power, due to elimination of a single long shaft and heavy belts carrying all the engine power. The cost, however, is based on an actual motor output of 90 hp. for a 3000-hour year, supplied from 25-hp. motors. All losses due to interruptions would, of course, disappear with installation of motors, and the speed of automatic machines should prove more uniform and satisfactory.

C. R. BEARDSLEY.

Bridgeport, Conn.

[It seems very evident that the oil engine under discussion either has had to contend with some very unusual adverse conditions, not brought out in the discussion, or else is one of those "black sheep" which occasionally get out of a factory and cast discredit on the other ninety and nine. Certainly, the average performance of oil engines is not as discouraging as Mr. Krah's lament indicates this one to be.

Mr. Beardsley fails to consider the use of steam for heating, in the case of the steam plant, and his fixed charge of $1.35 against the electrical equipment looks rather modest.—EDITOR.]

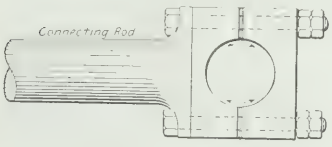
Some Notes on Gas Engine Bearings

BY J. E. LATTA

There is perhaps no more prolific nor frequent source of hot bearings than that of carelessness or a lack of skill on the part of the erecting engineer, or, what amounts to the same thing, on the part of the man drawing the plans to be followed by the erecting engineer. If, for example, the foundation of an engine is so designed that there is appreciable vibration in the running of the machine, serious and frequent trouble with the

bearings is almost inevitable. In one case an 80-hp. engine vibrated so badly, even when running at only half load, as to produce an annoying rattling of the windows in residences 200 yards away, while the shaking in some railway offices half that far away was so violent that the clerks constantly complained of its interfering with their writing.

The engine was of the twin-cylinder type, with six crankshaft bearings. To keep them from becoming very hot, very often, proved to be altogether out of the question. While this is decidedly the worst case of vibration that has ever come to the writer's attention, it is but one of a number of personal observations of the necessity of smooth, steady running on the part of engines and other machinery. If correctly designed and properly erected, the average engine, no matter what the type, will run practically free from appreciable vibration. It cannot usually be expected to do this, however, if the foundation does not rest



CLEARANCE ARCS OF CRANKPIN BRASSES

on a solid support, nor if the foundation is too small and therefore too light. It is a truth which needs emphasis that the man who is erecting an engine should not forget that a generous use of concrete in the foundation may mean a great future saving in oil and babbitt and service interruptions.

On certain types of engine the crankpin box is liable to be a source of considerable annoyance during the first few months the engine is run. Sometimes there will be sufficient pounding to reduce the thickness of the babbitt lining rather rapidly, making it necessary to take up the bearing more or less every few days. Moreover, it may happen that the babbitt will be hammered out at the edges so much that the connecting-rod will be left with such a small amount of side play at the crank end as to make it difficult for the engineer to determine, in adjusting the bearing, just when it has been taken up enough. In such an event it becomes necessary, of course, to scrape the edges slightly; but care must be taken not to cut away too much of the babbitt, for if the crank end of the connecting-rod is given too much freedom of motion along the pin, heating is quite liable to result.

It is good practice in starting up a new engine to scrape the crankpin bearing lightly along the arcs indicated by the double-headed arrows in the accompanying sketch. Since this portion of the bearing is never called upon to do much work, there is no reason why it should fit the pin as snugly as the rest of the bearing surface.

It took me several years to learn that the babbitt in the crankpin bearing may be broken by the pounding which is a too common accompaniment of the running of many engines. This sometimes happens, and, what is worse, a piece of the broken babbitt may become lodged in an oil groove and cause the bearing to be burned out. For some reason or other, it is usually the babbitt in the outer or forward half of the box which breaks. In gas or oil engines, this breaking may be caused by the shocks due to preignition of the explosive mixture. I have known engineers to spend many weary hours in futile efforts to adjust a crankpin box so as to stop it from pounding, when a few gallons of a mixture of one-third of commercial muriatic acid to two-thirds of water, by volume, run through the cooling jackets of the engine cylinder to clean out the mud, lime or other formations therein would have silenced the pounding by stopping premature ignition.

CORRESPONDENCE

Points in the Care of Oil Engines

Below are replies to the points raised by S. G. Rose in the Nov. 28 number of POWER concerning my article in the Oct. 24 number:

1. Although the ignition tube may have been heated up enough to enable the engine to be started, this may have been—and generally is—accomplished by pumping the lamp pressure up to point which may be more than twice the pressure obtaining when running. The result, especially with light loads on a "hit-and-miss" engine, may be that cooling of ignition tube will occur after the engine has been started up. The cooling may be due to faulty burning of the lamp at the working pressure, to the ignition tube being too long or of too great a diameter, or to its orifice being partially choked up with carbon. Mr. Rose is right in his supposition that the engine will not start at all if the ignition tube is not hot enough in the beginning.

2. First of all, it is not every make of engine, by any means, which is provided with a timing valve. Then, it often happens that, with the ignition tube at its normal heat for normal running, an overload will come on, causing the tube to get considerably too hot, with resulting preignitions. This is certainly not to be classed as one of the commonest of oil-engine stunts, but it does occasionally occur and Mr. Rose may possibly be able to trace a "mysterious" trouble to it some day. Mr. Rose's experience as to preignitions with electric ignition is not uncommon, but, as mentioned in my original article, the troubles peculiar to electric-ignition devices are sufficiently numerous to justify an article to themselves.

3. I am aware that the majority of oil-engine handbooks and instruction manuals tell one to keep all valves closed when the engine has stopped. By all means do this when the exhaust line may have any pressure above atmospheric introduced into it by any means, as by the connection of the exhaust pipe of another engine. In my oil-engine experience, however, I have found that if the exhaust valve is left open when the engine is shut down, the pitting and corrosion of its face and seating surface will be greatly minimized. Why this should be so I have not decided quite to my satisfaction, unless it is due to the fact that any moisture which condenses in the cylinder may drain right away instead of being held for some time while it percolates through the annular nick between the exhaust valve and the seat.

In engines fitted with electrical-ignition apparatus the chief argument against leaving the exhaust valve open when the engine is standing is that moisture due to the condensation in the exhaust connections may settle on the plug points. This is the cause of "damp plugs" which often give difficulty in starting up. This trouble is nonexistent in hot-tube ignition.

JOHN S. LEESE.

Manchester, Eng.

Two Cycle Gas Blowing Engines

We read with great interest Mr. A. G. Christie's article on "Developments in Prime Movers," in POWER of Oct. 24 last, and we take the liberty of stating that his view that at present two-cycle engines are almost exclusively used in the German iron works for driving gas blowers, does not quite accord with the actual state of affairs.

Up till now this company alone has installed in such works approaching 90 gas blowers, aggregating aproximately 150,000 hp. and of such engines eight, aggregating 30,000 hp., are being used for driving gas blowers in steel works, while only one or two gas blowers of the two-cycle system are used for converters. The number of four-cycle engines just stated will be increased by the many four-cycle gas blowers supplied by the firms Thyssen, Erhardt & Sehmer, Haniel & Lueg, Friedrich-Wilhelms-Hütte, Mülhausen and others.

It will be evident from the foregoing that the number of the four-cycle gas blowers in use in Germany far exceeds that of the two-cycle gas blowers, although for some time a preference existed for the latter type.

MASCHINENFABRIK AUGSBURG-NÜRNBERG A. G.,
per KUTZBACH and P. MEYER.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Rebuilding Radiators

By L. M. Johnson

In a large Pittsburg office building there has been considerable trouble experienced with the steam-heating radiators. Of the 160 radiators in the building over one-half of them have been rebuilt in the past two years, while the building has been constructed and occupied only ten years.

Attention was at first drawn to the radiators by an occasional leak between two columns. This was at first remedied temporarily by slightly spreading the two columns, wrapping some tape saturated with pipe cement around the nipple and then pressing the columns together again. This was found to be a short-lived repair as the radiators soon began to leak again. As other radiators began to show signs of leaking it was necessary to give the subject more serious attention and find a permanent repair. It was not considered advisable to throw the radiators away and put in new ones, so the method of repair outlined in the following was adopted.

The construction of many radiators consists of a series of cast-iron columns connected together at the bottom with smooth-face, tapered nipples, commonly called slip nipples. One of these nipples is entered into the reamed hole of a column and another column is placed parallel with it and the end of the nipple started in the opening and then pressure applied until the shoulders of the two columns are pressed together, so that the nipple has an exceedingly tight fit in both columns.

After securing the necessary tools and nipples the order of repair was to take the radiator out and separate the columns at the place which showed the leak, clean out the holes, put in a new nipple, press the columns together again and put the radiator back in service. This method did not prove satisfactory, as the strain on the unbraced columns while placing the repair nipple tended to loosen other nipples that were already becoming weak from corrosion and cause them to start leaking. After this experience it was deemed advisable to take the radiators apart and renew all of the nipples.

Before it was time to furnish heat for the present winter, all the radiators that had given any evidence of leaking were taken to the repair room to be rebuilt. The radiator was placed on a platform of convenient hight, the stay rods were taken out and then it was an easy matter to separate the columns by prying them apart with a long bar, as shown in Fig. 1. The nipples in some cases were so badly corroded that the columns could be separated with the hands. The old nipple, usually remaining in one of the columns, was easily removed by caving in the weakest side and then driving it out from the opposite side with a drift. The holes in the columns were then cleaned out with emery cloth until they were smooth and bright. A new nipple was dipped in a thin mixture of white lead and entered into the column, as in Fig. 2. Another column was then placed parallel to those already assembled and started square on the nipple. When three or four columns had been placed together the screw press and chain were put on and with the assistance of a heavy piece of babbitt metal as a bumper the columns were pressed together, as shown in Fig. 3. These operations were repeated until the radiator was completed. After the radiator has been rebuilt in this way it is apparently as good as new.

Fig. 1. Prying the Columns Apart

Fig. 2. Inserting a Nipple

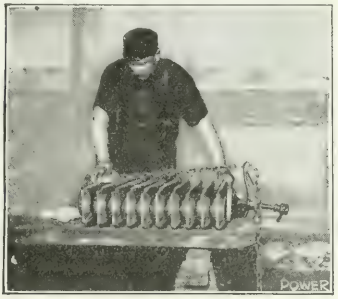
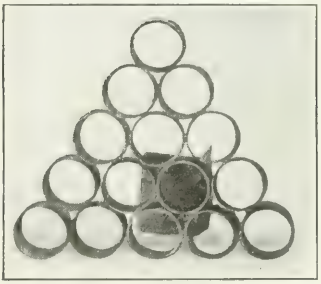


Fig. 3. Pressing Columns Together

In Fig. 4 is shown a pile of nipples that were taken out. It may be noticed that some of the nipples have been corroded all the way through on one side, leaving an opening which was always found on the bottom. A stack of new nipples is also shown in Fig. 4.

Corroded Nipples



New Nipples

Fig. 4.

All the steam-pipe connections were tapped for 2-inch pipe, but the contractor who installed the radiators, evidently to reduce the cost of piping, had reduced the size to the radiators. In the twenty-

three-column radiator the opening was bushed from 2 to 1½ inches; the opening in the thirteen-column radiator was bushed from 2 to 1¼ inches, while the connections in some seven-column radiators were reduced from 2 to 1 inch. A few larger radiators on the first floor were piped with the full-size 2-inch pipe. These gave no trouble, as the 2-inch pipe permitted the radiator to drain below the connecting nipples, while all those that were bushed would not drain below the nipples, thus leaving some water lying on the lower side of the nipple. The radiators with 1-inch connections were the first to give trouble and so on down. It is thus apparent that economy in the piping of the radiators greatly shortened their life.

FIG. 1. A BLOWER ON EITHER SIDE OF CRANE WAY

Heating a Large Shop

A clear conception of the fan system of heating and ventilating an industrial building may be obtained by a glance at the accompanying illustrations. They are views of the new machine building of the Union Drawn Steel Company, Beaver Falls, Penn. The building is of modern construction throughout, being of brick and steel with Fenestra steel sash occupying a large part of the wall. The roof is of concrete about 2½ inches thick and covered with a tar and gravel roofing. The monitor is continuous steel sash.

In this case, on account of the crane way, two separate sets of heating apparatus were installed. Each apparatus consists of a 100-inch double-discharge conoidal fan, direct connected to a 7x7-inch single-cylinder vertical Buffalo engine. The air is drawn through six sections of return-bend heater coils, and delivered to the galvanized-steel ducts which distribute it to all portions of the building. The steam is delivered to the engines at 75 pounds pressure and the exhaust is used to heat the coils. The entire system has a capacity of raising 50,000 cubic feet of air per minute from a temperature of 0 to 110 degrees.

At the same time that this installation was made, a somewhat similar heating and exhausting system was placed in the pickling room of the same company.

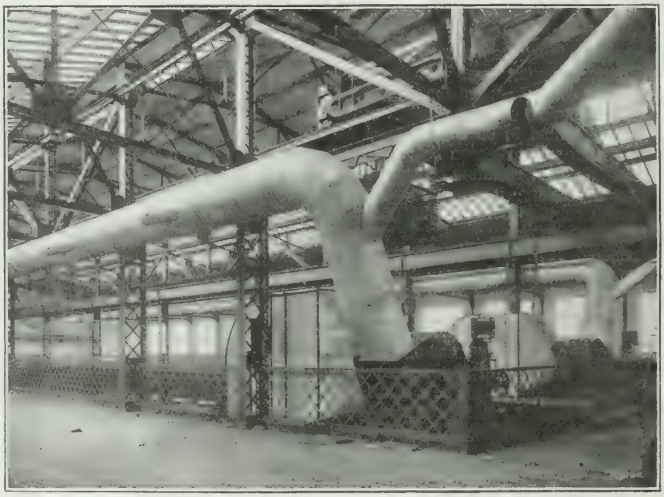


FIG. 2. THE GALVANIZED-STEEL AIR DUCTS

Albert M. Allen & Co., of Cleveland, were consulting engineers for the Union Drawn Steel Company and under their specifications the heating and ventilating systems were installed by the Buffalo Forge Company.

Air Circulation

BY HENRY D. JACKSON

There are many heating installations in which no arrangement has been made to insure a proper circulation of the air, so that the heating is decidedly ineffective. To heat a large space effectively, a thorough circulation of air is necessary; otherwise the hot air will rise to the top of the room, cold air will settle to the bottom, and the gradation of temperature from fairly cold at the bottom to very hot at the top will be the result. This condition has been found in many armories, dance halls, drill halls, etc., where, owing to the requirement that the floor space be not obstructed, the heating coils have been placed high up on the walls and across the building, approximately at the hight of the eaves.

In one instance coming to the writer's notice, all of the heating coils were suspended directly under the trusses supporting the roof, and the steam coils had a capacity representing about 1 square foot of heating surface to 50 cubic feet of building contents. With a pressure of 10 pounds at the coil valve, the temperature on the floor was about 40 degrees during zero weather, while the temperature at the peak of the roof was in the neighborhood of 125 to 130 degrees. To overcome this difficulty, six holes were cut in the floor of the building, one-quarter of the steam pipe was put under the floor, one-half was cut out of service entirely, and one-quarter was left as it was. Heavy grates were placed over the holes and at three of them heavy tin pipes were fastened, extending to within a foot of the ground below the floor. The steam pipes under the floor were placed about one foot below the

floor proper. After these changes were made, steam at a pressure of two pounds was supplied, and within half an hour after it was turned on the coldest place in the room was at 67 degrees. Since these changes were made, more trouble has been experienced in keeping the room cool than in keeping it warm.

Of course, the heated air under the floor rose through the three registers provided for it, and in rising left a space for the cold air on the floor to circulate. This air on being heated will rise and the cold air on the floor will drop, thus giving a thorough circulation of air all through the building.

In most hot-air heating, the location of the registers is decidedly faulty. For proper and active circulation of heat, the hot-air entrances should be approximately 7 feet from the floor and on the walls opposite to the window, so that the hot air on entering the room will rise, flow over toward the windows and, being cooled by this radiation from the windows, will drop to the floor. If the outlets for this air are placed at or about the floor level, the air will circulate along the floor to these outlets and up the exhaust stack.

If the circulation is rapid enough, the difference in temperature between the bottom and the top of the room will not be noticeable, and not only will the temperature be more uniform, but the fresh air brought in through the furnace will enable the occupants to live more comfortably at a much lower temperature. The air supplied should be properly moistened before it enters the supply pipe, as moisture has a marked effect upon the temperature at which one can live comfortably.

LETTERS

A Water Heater Problem

The scheme described by N. S. Rice in the Dec. 5 number to heat water for the office would doubtless work as described, although I would imagine cooling part of the feed water after it leaves the heater would not be good practice.

If the drip or condensation from the heater were run through the small tank there could be no objection; a drip or return from a few radiators, during the cold weather, would also do the trick, the ¾-in. brass pipe being used in either case.

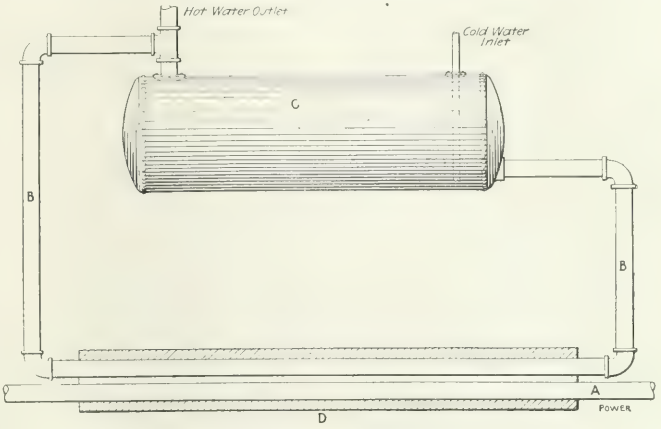
When such a small quantity of water is required, a scheme such as is shown in the accompanying illustration could be used. Here *A* is a live-steam pipe, *B* a circulating pipe, *C* the reservoir for hot water and *D* indicates pipe covering.

As may be observed, the circulating pipe passes through a piece of pipe covering and is in contact with a steam pipe.

If there is a hotwell into which drips and condensation return and from which the water is pumped to the heater, another plan could be used. Instead of placing a pipe in contact with a hot pipe, as suggested above, it could be submerged in the hotwell. Any of these schemes would supply the apparently small quantity of water necessary in the case in question, and none of the boiler-feed water would be reduced in temperature.

JAMES THORN.

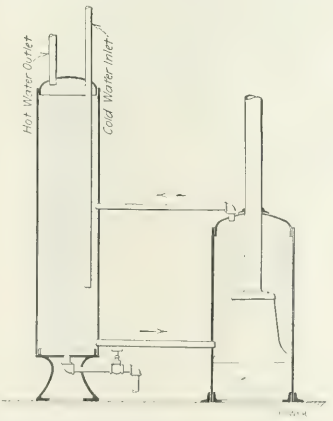
Toronto, Can.



SCHEME FOR HEATING SMALL QUANTITY OF WATER

Piping a Water Heater

In looking through some of the back issues of POWER, I happened to read Mr. Noble's letter on connecting up water heaters. In my opinion, his method is at variance with the common principles of water circulation. Does Mr. Noble expect the heated water to fall down to the bottom of the tank or is it to be used as heated? The manufacturers put the hole in the middle of the tank so that there will be a thorough circulation of water and always a one-half drum of hot water in reserve. I have connected up hundreds as shown in the attached sketch, and they have always given satisfaction.



PROPER CONNECTIONS FOR GOOD CIRCULATION

In his letter appearing in the Nov. 21 issue, my opinion is that the saving will be chiefly on paper. The designer decided that a 5-in. exhaust was required; then somebody comes along and partially blocks it up. This will cause a higher back pressure. The engine naturally takes more steam to drive a given load, and it will take very little more steam to "eat up" one ton of coal a week on that size of engine. The exhaust line appears to have enough elbows and length without blocking it up. From the elbow to the tee, shown in the sketch, the size of the pipe should have been increased to 6 inches.

The outlet of the coil should enter the drum about the middle of its length, so that the lime will be precipitated and not scale up the pipes. The circulation being constant, the drum would not then be subject to the violent shaking and hammering that takes place when it is connected up as indicated in the sketch.

H. JONES.

Montreal, Can.

Petroleum has been found in Alaska, and while there has been practically no production, it is not impossible, according to the United States Geological Survey, that commercial pools may be found. Oil seepages occur on the west shore of Cook Inlet, on the east side of the Alaska Peninsula, and on Controller Bay, all close to tidewater, and hence capable of cheap development.

United States Overfeed Stoker

The American Stoker Co., 11 Broadway, New York City, has placed upon the market an overfeed stoker, which is shown in the accompanying illustrations.

It consists of an ordinary fuel hopper in the bottom of which are reciprocating, adjustable pushers, which shove the coal into the furnace upon the top grates. The back plate of the hopper, which is exposed to the furnace fire, is water cooled to prevent the destruction of the plate by the furnace fire, and also to keep the plate so cool that the coal will not fuse in the hopper and prevent the proper feeding of the fuel.

A short pusher is employed at each side of the stoker to provide means for feeding fuel to the sides of the grates irrespective of the amount of coal fed to other parts. This provides a means of preventing air holes forming along the side walls of the furnace.

The grate surface (except the ash dump) is composed of a series of horizontal shelves arranged as steps, as shown in Fig. 1. They extend across

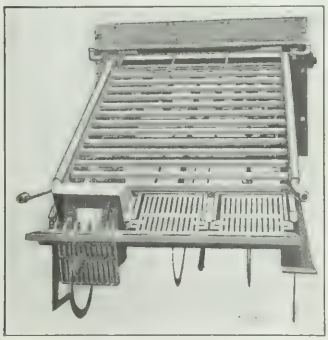


FIG. 1. SHOWING TERRACED GRATES, DUMPING GRATES AND CUTOFF PLATE

the furnace and form an incline of about 36 deg., thus providing abundant air space between the grates. The grates are formed of two series, alike in design, but arranged alternately fixed and moving, as shown in Fig. 2. The fixed grates are bolted to the side risers adjacent to the furnace walls and additional stationary risers extending through the center portion of the stoker. The moving grates are interleaved between the fixed grates and are supported and securely bolted to moving risers, which are supported at the lower end by rollers and at the upper end by arms attached to eccentrics mounted on the stoker shaft.

By an arrangement of a knuckle-joint swing link and setscrews the motion of the grates may be modified to suit the particular requirements of different kinds and grades of fuel. For a coal subject to coking, the grates may be adjusted to travel in the path of an ellipse, as shown by the dotted lines in Fig. 2; or the grates may be changed so that the forward motion may be a straight line, while

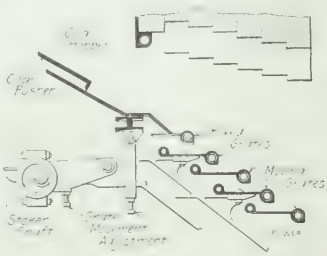


FIG. 2. MOVING AND FIXED GRATES

in retreat the grates may lift more or less than in the arc of an ellipse, carrying the grates clear of loose coal which may be on the rear of the grate below. The motion of the grates is such that the coal is compelled to travel at a uniform thickness from the top or front of

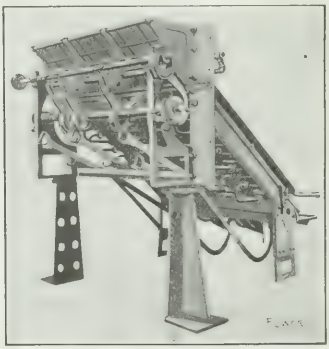


FIG. 3. FRONT ELEVATION OF STOKER, SHOWING ACTUATING MECHANISM

the furnace to the rear. Each grate assumes the rôle of a positive pusher in its relation to the next. This applies to the coal and burning fuel and the ash and clinker also, so that the latter are precipitated upon the ash dump at the rear and bottom. As the grates overlap, even fine fuel will not sift through the grates.

The ash and clinkers are extracted and separated from the good fuel by the attendant by the simple operation of the parts, and, during the process of dumping or after, cold air is not admitted to the furnace as the space occupied by the dumping grate is covered with burning fuel. Fig. 1 shows the special dumping arrangement.

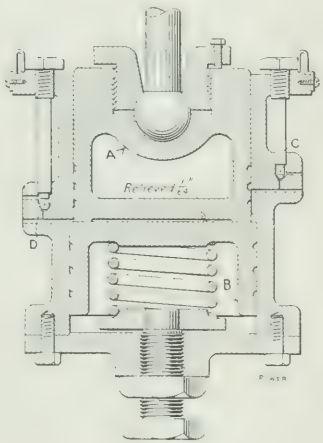
Partly embedded in the bridge-wall is a "water back" cylinder which is constructed of standard steel boiler plate and connected direct with the water circulation of the boiler. It is provided with standard-size boiler manhole and blowoff pipe for cleaning. Its purpose is to prevent the adhesion of clinkers to the bridge-wall.

Each grate bar is protected from burning by a continual stream of water passing through that portion which is in direct contact with the burning fuel. The pipes used for this purpose are extra-heavy, cold-drawn seamless tubing and are tested under a pressure of 1000 lb. per square inch, and are cast in the grate. The connections from one grate to another are made by U-shaped pipes with unions having ground ball bronze seats. The connection is shown in Fig. 2.

Treating the moving grates as one unit and the stationary grates as another, water connection is made direct with the boiler to the bottom grate of each series, thence ascending from grate to grate until the top is reached, where another connection leads to the steam space of the boiler. There is no moving joint in connection with the entire installation.

Miller Quick Acting Vacuum Pot

The accompanying illustration shows a cross-section of a Miller vacuum dashpot. When the plunger *A* is released the air which was taken in through the air valve *C* is discharged through the ad-



MILLER QUICK-ACTING VACUUM POT

justable check valve *D*. When the plunger *A* drops, the piston *B* will take the thrust noiselessly and without a jolt, due to a cushion of air and the give of the spring, which is strong enough to quickly reseat the piston *B*. This action forces out the remaining air and causes the plunger to seat quickly. The air valve *C* can be adjusted to diminish or increase the

amount of air taken into the cylinder to suit the spring, which is also adjustable.

This device is the invention of F. B. Miller, 147 Fourth street, Milwaukee, Wis.

Wheeler Barometric Ejector Condenser

This condenser has been designed to operate in connection with reciprocating engines where a high vacuum is not demanded for economical steam consumption and where a short exhaust-pipe connection is not essential.

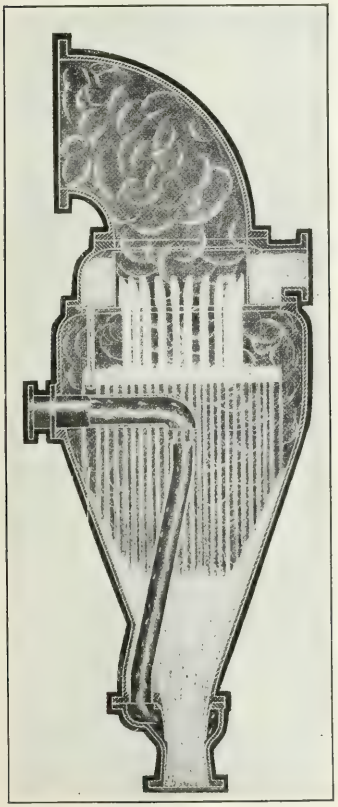


FIG. 1. INTERIOR VIEW OF BAROMETRIC EJECTOR CONDENSER

The condenser consists of a pear-shaped body, Figs. 1 and 2, with a large exhaust-inlet opening at the top and an opening at the side for cooling the water. At the bottom, connection is made to the barometric column which discharges the water to the atmosphere without the aid of a tail pump.

The sectional view, Fig. 1, shows that the condensing water is distributed in an annular reservoir which has vertical slots in its inner wall through which the water falls in numerous small streams in the direct path of the exhaust steam.

The falling water from this annular distributer is collected upon the tray placed immediately beneath and is distributed so as to fall through the small openings in this tray in a fine rain to the bottom of the condenser, where it again comes in contact with the exhaust steam.

Air may be drawn from the condenser either by the water ejector or by both the ejector and a dry-air pump which may be connected to the opening shown at the left of Fig. 1. As the water falls down through the condenser shell air is

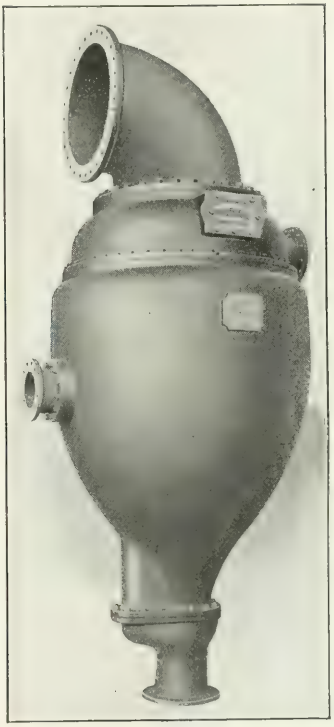


FIG. 2. EXTERIOR VIEW OF EJECTOR CONDENSER

entrapped and is carried out through the converging nozzles of the shell, and at the same time the water acquires a higher velocity so that at the neck of the condenser an ejector action is set up. The air supplied through the lower pipe, shown in section, is thus carried out through the ejector to the atmosphere. The barometric column attached to the bottom of the condenser is approximately 34 feet in hight, which insures that the water and air will be delivered to the sump at the foot of the column against the pressure of the atmosphere.

For intermittent service this condenser will maintain a good working vacuum without the use of an air pump. Where the conditions are such that a better vacuum is desired, a dry-air pump used in connection with the condenser will maintain a vacuum up to 29 inches of mercury.

This condenser is manufactured by the Wheeler Condenser and Engineering Company, Carteret, N. J.

The "Hypress" Blower

Simplicity in small pieces of apparatus is highly desirable for the reason that the small machine is often the victim of

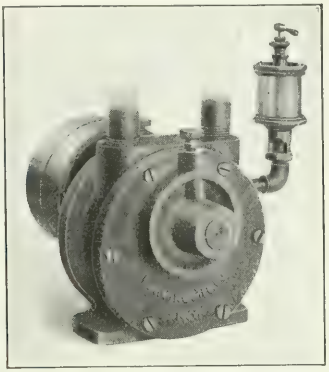


FIG. 1. THE "HYPRESS" ROTARY PRESSURE BLOWER

gross neglect. Once it is put into operation it must go on and on with hardly a glance from the man who has charge of it. Often it is installed where there is no one who has much, if any, under-

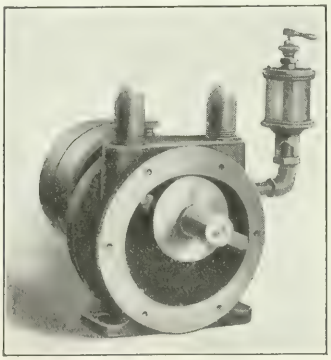


FIG. 2. BLOWER WITH COVER REMOVED

standing of machinery, and hence it receives no intelligent attention whatever.

The rotary-pressure blower which is illustrated herewith and which is named "Hypress" by its manufacturer, the L. J. Wing Manufacturing Company, was de-

signed with these facts in view. Its construction is simple and it has about as few moving parts as a blower well could have. It consists of a cast-iron casing in which an eccentric drum revolves; see Fig. 2. This drum carries a steel sliding vane fitted with self-adjusting rollers at its ends which make a practically air-tight contact with the wall of the casing.

The air is compressed during its passage from the inlet to the outlet of the blower. It is said that the efficiency of the blower is unusually high.

These blowers are manufactured for normal capacities of from 80 to 8000 cubic feet of air (actual) per hour at 2 pounds pressure.

Lalor Automatic Stop Valve

This valve has been designed to automatically stop the supply of oil in case of breakage of the oil lines or abnormal flow to the burners. Its action is automatic, closing and remaining closed until it is manually opened.

There is but one moving part to the valve, the plunger, which is entirely inclosed and so protects the valve that it cannot be held in an open position or become clogged by foreign substances in the oil.

In Fig. 2 is shown a sectional view of the valve in an open position. The flow of oil is toward the lift and upon entering the valve body it passes to the inside of the plunger, through the ports shown, and out to the pipe line.

If the pressure in the discharge pipe drops, the spring will draw the plunger down to a position where the port openings will be below the valve seat. With a uniform oil pressure in the pipe the pull of the spring is counteracted and the plunger will remain in the position shown. When the valve has once closed it is necessary to reset it again by lifting up on the hand lever, to which is attached the piston stem, as shown. After the tension of the spring has been adjusted for a certain maximum flow of oil, the valve will operate as soon as the maximum flow is exceeded. This valve is manufactured by the Lalor Fuel Oil System Company, 1326 Chestnut street, Philadelphia, Penn.

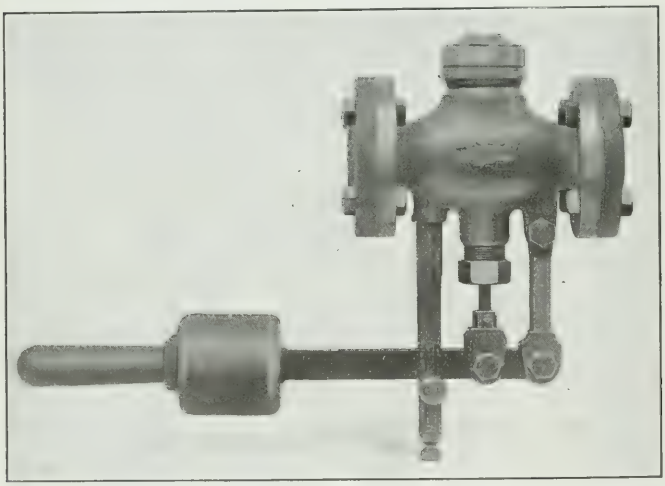


FIG. 1. LALOR AUTOMATIC STOP VALVE

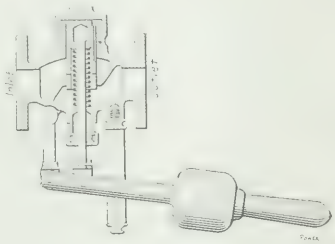


FIG. 2. SECTIONAL VIEW OF VALVE

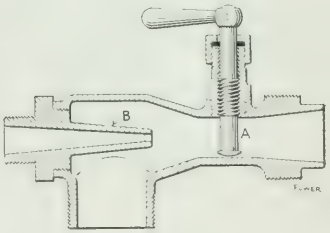
Water Ejector with Priming Attachment

The difficulty of starting up promptly with the ordinary design of water-lifting ejector is claimed to be obviated by the use of the new patent water ejector made by the Penberthy Injector Company, of Detroit, Mich.

This ejector may be operated with any fluid under pressure but it is designed more particularly to be operated with water. It is composed of a casing so shaped as to permit the delivery tube to be formed integral with the main casting without projecting into the suction chamber. This gives an unobstructed passage through the ejector and allows its use for handling sewage that has coarse matter in suspension.

This ejector also finds service within the limits of use of other ejectors and, in addition, can be used to lift liquids from below when operated with water of low or high pressure or with other fluids except gases, but it may be operated with air to handle gases or air. When used lifting from below it has an advantage over the ordinary ejector in that it is provided with a lifting attachment or primer. The primer is threaded into the discharge neck of the ejector and is composed of a screw stem and handle. When priming the ejector, the stem is screwed in so that it extends across the delivery-jet bore, as shown at *A*. The stem in this position is directly in front of the operating fluid which leaves the outlet of the power tube *B*. The stem parts the operating jet and this jet, on account of being parted and broken up, completely fills the delivery-jet bore, so that there can be no back travel of air through the discharge branch of the ejector into the suction branch. A strong partial vacuum is, therefore, readily attained and when the lift is accomplished, the stem is screwed out and free passage is given.

This ejector is made in sizes accommodating the various sizes of iron pipe and hose, and some of the uses to which it is adapted are the raising of thick liquids and sewage, draining trenches where tiling or water piping is being laid, the ejector being operated by water from neighboring hydrants. They are also used for filling spray rig or other tanks, water being furnished to them under pressure by a pump driven by a gasolene engine. In such service, the utility of the ejector is such that 14 gallons of water may be lifted from a depth of 22 feet with a consumption of but 6 gallons by the ejector.



SECTIONAL VIEW OF EJECTOR

Already, many exhibitors have taken space at the power show to be given at the Mechanics Building, Boston, Mass., Apr. 22 to 27, and all firms interested in power-producing machinery are urged to assist in making the coming power show the greatest and most successful exhibition ever held in the United States.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 30,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Looking Back over the Year 1911

A retrospect of the power field for the year just past reveals great activity in the development and perfection of the steam turbine. With the exception of Tesla's series of disks between which steam passes and causes rotation, nothing new or startling appears; but a number of tests showing remarkable economy have been made and individual units have been increased greatly in size. Close readers of POWER will require no reminder of the test conducted at the Dunston power station of the Newcastle-on-Tyne Electrical Supply Co., where a 6000-kilowatt Parsons turbine showed a thermal efficiency of 76.4 per cent. and developed a kilowatt-hour on 11.8 pounds of steam. The installation of a 27,000-horsepower Curtis turbine at the Waterside No. 1 station of the New York Edison Co. was a notable event, for, at the present writing, this is the largest turbine in the world. The unit, which is the first of three similar machines to be installed, is 35 feet high, covers an area of 297 square feet and weighs 420 tons.

Combination turbines using an initial velocity or Curtis stage followed by Rateau or Parsons pressure stages have continued to make strides in Europe, and are now manufactured by nearly all the companies which formerly built the straight types. The simple-velocity stage replaces a multiplicity of small blades in the initial part of a turbine of the Parsons type and confines the high pressures and temperatures to the steam chest, greatly reduces the length and complexity of the turbine, and diminishes the weight by permitting higher speeds.

Another effort in the direction of reducing the number of stages is that of Patitz. Since the energy in the moving jet varies as the square of its velocity, three-quarters of its energy will be abstracted by reducing its velocity one-half. Instead of getting up a low velocity like Rateau or Zoelly and abstracting it more or less completely at each stage, Patitz gets up a high initial velocity, takes out about one-half of it, and without further reduction restores the high velocity by further expansion, converting this much more energy per stage.

In marine work, turbines designed for high pressure and those utilizing exhaust steam from reciprocating engines have been viewed with increasing favor, and as a noteworthy example of the latter the mechanical equipment of the "Olympic" may be cited. From two 15,000-horsepower triple-expansion engines driving the outside screws the exhaust is passed to a 16,000-horsepower low-pressure turbine on the middle propeller.

In the merchant marine, and particularly in those vessels equipped for passenger service, the high-pressure turbine has made an enviable record, but in naval circles, where cruising at low speeds is common, the turbine has failed to come up to expectations. As a result of the comparative trials of the scout cruisers "Birmingham," "Chester" and "Salem" and the more recent tests of the battleships "Delaware" and "North Dakota," the United States Government favors the reciprocating engine, and, in addition, has decided to try oil fuel in some of its latest battleships.

Reduction gearing, now available in capacities undreamed of a few years ago, promises to do much to reconcile the differences between the steam turbine and the propeller, and to make the steam turbine available in wider fields. As a means toward the same end, the Foettinger hydrodynamical gear may be mentioned and also the electrical method of using a generator and induction motor between the turbine and the propeller. In large powers the electrical losses would not amount to more than 8 per cent. as compared to 2 per cent. for the gearing in perfect condition. On the other hand, the projectors of the electrical method offer a highly increased efficiency of the turbine and a very considerable reduction of the aggregate weight and space, due to the higher speed at which it would be possible to run it.

Even the rolling-mill field, which has always been considered the last and most

secure stronghold of the reciprocating engine, has been invaded by the aid of reduction gearing. The turbine, which was of the mixed-pressure type and installed at the Calderbank Steel Works of James Dunlop & Co., was rated at 750 horsepower and ran at a speed of 2000 revolutions per minute. This was reduced to 70 for the mill and a 100-ton flywheel absorbed the shock.

With the introduction of large turbine units, a corresponding increase in the size of boilers might naturally be expected. The year has witnessed the successful putting into operation of the largest boilers yet constructed, those at the Delray station of the Detroit Edison Co. At the common rating of 10 square feet of heating surface per horsepower, each boiler has a capacity of 2365 horsepower and is capable of caring for a turbo-generator load of 6000 kilowatts regularly and 8000 kilowatts at the peak. In the most stupendous boiler test ever reported, requiring the continuous service of over fifty men for nearly three months, these boilers showed the highest efficiencies ever obtained with bituminous coal. They were in a measure anticipated by a 2500-horsepower unit of Hornsby boilers ordered by the Hartford Electric Light Co. and described in our issue of Feb. 28. Before their installation, however, it was decided to throw up a curtain wall in the furnace and separate the sections, thus dividing the unit into two of 1250 horsepower each.

Accidents to boilers have been numerous, as indicated by reports for the first six months of the year. During this time 272 accidents occurred, including "real" explosions, tube blowouts (of which there is an increasingly large proportion) and blowoff failures on stationary, locomotive and marine boilers. The fatalities total 138 and doubling this number would indicate a death list approximating 250 for the year.

The continued wholesale destruction of life and property in this country from boiler explosions is a national disgrace and warrants every effort which will tend to reduce it. Before much can be done in this direction every state in the union must have adequate license and inspection laws, and these should be as uniform as possible. In this direction the most notable step in advance has been taken by Ohio, where a board of boiler rules practically identical with that of Massachusetts and having similar powers has been appointed. It is to be hoped that other states will soon follow with similar laws which at least possess the virtue of preventing the installation of palpably unsafe boilers even though no steps are taken to eliminate those already in use.

Massachusetts itself has made some important changes in the application for examination and in the appeal therefrom. The horsepower rating of boilers has been altered slightly and a turbine rating appended. These and a number of minor amendments to its boiler rules went into effect the first of the new year.

Bills for the licensing of engineers have been introduced in the legislatures of New York, Connecticut, Rhode Island, Kansas and several other states, but have failed to pass.

Adoption and advancement of these laws, of course, require more from the engineer. He must know his profession thoroughly, and, as a means toward an end, the organization known as the Institute of Operating Engineers was incorporated and held its first convention during the summer. Its work is purely educational and its affiliation with numerous trade and correspondence schools gives the engineer every opportunity to work out his own education under competent guidance.

The tests to destruction of two 72-inch cylindrical boilers by James E. Howard indicate that other factors than those ordinarily considered should be taken into account in determining the safe working pressure of boilers; and continued investigations by this method are likely to have an important bearing upon the design of boilers, especially of the more complicated types.

Other important tests relating to boilers which should be enrolled in the year's work were those conducted by the United States Geological Survey, which tend to show that a solid boiler wall is a better heat insulator than a wall of the same total thickness containing an air space. The loss by radiation forms the basis for this conclusion which is contrary to the general belief.

A notable demonstration in the field of combustion is that of Prof. Bone, who shows that a combustible mixture of air and gas burns upon or below the surface of a porous plate without flame and with great intensity. An application to boiler practice is to inject such a mixture into the tubes of a boiler which are filled with broken refractory material. A boiler 10 feet in diameter and with tubes only 4 feet in length has been recently built for the Skinningrove Iron Co., Ltd., of Yorkshire. The normal evaporation is 21 pounds per square foot of surface and this can be doubled with small loss in efficiency.

Among steam engines the locomobile and Prof. Stumpf's uniflow type have attracted wide attention. The conception of these engines, of course, antedates 1911, but practical development has been made during the year and a great deal of discussion has been published on their relative merits.

In the gas-engine field steady, conservative progress has been made, but more particularly in Europe than in the United States. Engines of the four-stroke-cycle type are being built to develop 1500 horsepower per cylinder and 2000 horsepower working on the two-stroke cycle. It is in the Diesel engine that greatest progress has been made; the development has been phenomenal. This type of engine is seen everywhere in Europe and is much more common than any other recent type of prime mover. Several large ships have been fitted with Diesel engines and it is current report that the German navy is at present installing 40,000 horsepower of this type of engine in one of its new battleships. In Switzerland, multicylinder units of 2000 horsepower are in active service and, before long, single cylinders of 1000 horsepower may be expected.

The Grine crude-oil gas producer recently installed in Los Angeles, Calif., is worthy of mention. Its principle of operation differs from the ordinary in that the oil is atomized in the upper part of the generator and is passed downward through a bed of incandescent coke in the bottom of the generator where the heavy hydrocarbons are broken up and the tarry content fixed. Using crude oil costing 2.3 cents per gallon, it is claimed by the inventor that the same amount of power will be developed that the ordinary engine develops per gallon of distillate costing 7 cents per gallon in the same locality.

Electrical apparatus has become so well standardized that radical chances are not to be expected. Progress has been made, however, and it is most ap-

parent in the constantly increasing size of electrical machinery and apparatus. Motors up to 5000 horsepower are becoming common and at McCall's Ferry the 10,000-kilovolt-ampere transformers but recently installed are reported to be the largest ever built. In mine-hoist and rolling-mill work the electric drive has made a safe entry in the face of conditions which were previously considered prohibitive.

A recent example of the modern tendency of replacing the piston by machines employing rotary motion is the rotary air compressor, a machine exceptionally light and compact when compared to the immense blowing tubs now in common use. During the year one of these blowers was put into service at Oxford Furnace, N. J. It has a capacity of 22,500 cubic feet of air per minute, which is delivered at a normal discharge pressure of 15 pounds per square inch. In Europe pressures as high as 140 pounds have been attained.

While on the subject of gas the Thomas electric meter should be mentioned as an ingenious instrument which seems to promise a solution of the difficult problem of measuring gas and air in large quantities with considerable accuracy.

During the year there has been a great deal of agitation on governmental control of water power and no doubt the public conference held under the auspices of the power-transmission section of the National Electric Light Association did a great deal of good, as both sides of the question were thoroughly discussed before Secretary Fisher, representing the government. At the time of the meeting the government had not formulated any definite policy on the control of water power, but since then the secretary has made a tour of the West and has visited Alaska to look over the government coal lands, so that the conservation movement on both coal and water should receive the intelligent attention required from the government for a successful solution of these problems.

During the year there have been lost to the power field a number of prominent workers. In the first month of the year Louis R. Alberger, who was president of the Alberger Condenser Co., passed away. His life work as well as that of his father before him had been associated with condensing apparatus. He was soon followed by William B. Mason, president of the Mason Regulator Co., and inventor of numerous valve and engine appliances. Charles W. Hunt, president of the C. W. Hunt Co., and a former president of the American Society of Mechanical Engineers, at his death in March left an enviable record in the development of conveying and hoisting machinery, industrial railways and kindred lines. James C. Bradford, who built the boiler for the "Monitor" during the Civil War, died in April, and a few months later James C. Brooks, president of the Southwark Foundry & Machine Co., and George F. Hughson, holding a similar position with the Hughson Steam Specialty Co., passed away. Henry W. Bulkley, inventor of the first practical injector condenser, died in November, and during the latter part of the year the Westinghouse Co. of Pittsburg was unfortunate in losing two of its prominent officers: Robert Mather, chairman of the board of directors, and George W. Hebard, acting vice-president.

Prof. Stumpf's Criticisms

The discussion which has arisen between Prof. Stumpf and Mr. Heilmann, as a result of the latter's paper dealing with the heat efficiency of reciprocating engines, unfortunately has resolved itself into a bipartisan controversy regarding the relative merits of the Stumpf uniflow engine and the Wolf locomobile.

The tests forming the basis of Mr. Heilmann's original paper were made for the purpose of determining the influence of primary and secondary superheating and of vacuum upon the steam consumption of the locomobile engine; also, a careful study of the heat losses in both this type and the uniflow engine was made. From a purely technical standpoint the results form a valuable addition to the data already available upon the subject.

In conclusion, however, Mr. Heilmann offered some criticisms of the uniflow design, some of which, in view of the tests, seemed warranted; but he unwisely attempted a comparison between this type and the locomobile design, favoring, of course, the latter.

These criticisms, although mild, appear to have incited Prof. Stumpf to make a savage attack upon the paper, with an attempt to discredit its value by questioning Mr. Heilmann's intentions. In this he does not confine his attentions to the points at issue, but goes further and attacks the whole locomobile design. He says in this connection: "Separated from the boiler, the Wolf engine must be designated as the worst, because it has the largest clearances and the largest detrimental surfaces of all comparable engines, and in addition a combined inlet and outlet passage." However, the mere fact that this engine is placed in the uptake from the boiler precludes the necessity of many of these features, and it is manifestly unfair, if not ridiculous, to attempt to judge it separately from the boiler.

It seems most unfortunate that investigations of this character should not be accepted solely upon their scientific value regardless of personal and commercial motives. However, as is often the case, discussions often bring out more important points than those contained in the original statements. We are glad to see that some of our readers have appreciated the importance of the subject and have shown a disposition to discuss it.

One lesson to be drawn from the tests to destruction of a large horizontal return-tubular boiler by James E. Howard, as described on page 845 of our issue of Dec. 5, is that something more than the diameter, tensile strength and efficiency of the riveted joint must be taken into account in figuring the allowable pressure upon a boiler of this type. When the pressure applied reached 270 pounds, the cast-iron manhole frame was fractured across its center. If this had happened under steam pressure, it might have resulted in the destructive explosion of the boiler, and yet at the allowed pressure of eighty-five pounds it affords a factor of safety of slightly over three, whereas, figured in the usual way, the factor of safety was around five. It is true that the pressure was progressively reduced by the inspection and insurance company until at the end of twenty-seven years it had gotten down to fifty pounds; but it is not likely that the manhole frame was materially stronger at the commencement of the service of the boiler than it was at the end.

If you wanted to know whether the name of the Stirling boiler is spelled with an "i" or an "e," you could not find out from Professor Jacobus' paper on the Delray tests.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

A Case of Cylinder Distortion

A remarkable case of cylinder distortion, and the builders' remedy, which came under my notice, is illustrated by Figs. 1, 2 and 3.

This engine had a 12x20-in. cylinder and ran 232 r.p.m., developing about 100 horsepower.

The cylinder, Fig. 1, had been in use a number of years and was mechanically faultless, the only defect being its excessive clearance.

The builders of the engine designed a cylinder and exhaust valve whereby the clearance was reduced nearly one-half. They also changed the steam side, which made the new cylinder casting the shape of Fig. 2.

When the work of installing the new cylinder was finished and the engine

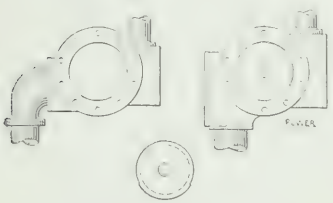


FIG. 1. FIG. 3. FIG. 2.

started up with steam at 40 lb. pressure just to see that everything was clear, also to prove the adjustment of the valves by the indicator, everything was found to be satisfactory.

Before putting the engine at its regular work, I was careful to heat the cylinder as much as possible before starting time, and before and after starting up I gave the cylinder an extra supply of oil.

After running nicely about half an hour with the regular steam pressure of 85 lb., the speed slowed down, but after a minute gradually came up again; this action was repeated several times during the first hour's run.

After the day's run I took the cylinder head off and the condition of the cylinder was a surprise to me, as it was roughed up the whole length, on both sides, they having drawn in and gripped the piston. The top and bottom of the cylinder had evidently gone outward, the cylinder becoming elliptical.

The counterbore was round when the cylinder cooled off; therefore the destructive distortion may be attributed to the change of temperature due to the difference in the pressure of the steam at 40 and 85 lb., which is less than 50 deg. The primary cause was the distribution of the metal in the different cylinders. The cylinder was returned to the shop, where it was rebored and a new piston made for it, Fig. 3.

This piston was of the solid type and packed by two narrow rings made in one piece and sprung into grooves near each end. It was first turned in the lathe to the exact diameter of the cylinder and then around two-thirds of its circumference it was reduced about $\frac{1}{32}$ in. by planing it on centers. The turned surface of the piston bore on the bottom of the cylinder through about 120 degrees.

The packing-ring joint was kept at the bottom of the cylinder by a pin set in the grooves between the ends of the rings. Here the joint is packed by the contact of the piston itself with the bottom of the cylinder so that steam cannot blow from either end of the cylinder past one ring to the other.

Cylinder No. 1 was again displaced by No. 2 with good results and gave no further trouble.

J. W. PARKER.

Clinton, Mass.

Timely Discovery of Serious Lap Crack

In the forenoon of Dec. 2, a lap crack was discovered in the rear course of the boiler owned by O. S. Cook, a box manufacturer, of West Fitchburg, Mass. Engineer W. F. Dennihan noticed a small amount of steam coming up through the brickwork the day before. As a brace rivet had been calked there a short time before, he thought that this rivet was leaking again, and did not give it much attention. Saturday morning, Mr. Dennihan noticed that the leak was increasing and immediately decided not to run until noon, but to lower the pressure at once and investigate. (This was in opposition to the wishes of the owner, who wanted to run until noon.)

After tearing off the brickwork, a crack 5½ in. long was found coming through the outside of the lap at the inside edge of the rivet heads. The inspector for the insurance company was called and he immediately condemned the boiler. Taking a heavy hand hammer the inspector pounded along the joint, beside the rivet heads, and the crack continued to open up for a distance of about 30 in., which was as far as the brickwork had been removed at the time.

This boiler was built 11 years ago. The dimensions are: Shell, 48 in. by 14 ft.; shell plates, $\frac{5}{16}$ in.; heads, $\frac{7}{16}$ in.; tensile strength, 55,000 lb.; the boiler had fifty-two 9-in. tubes.

The joint is a double-riveted lap; the pitch of the rivets is 2¾ in.; the efficiency, 72 per cent. The pressure allowed was 90 pounds.

It is said that the former state inspector intended to cut the pressure to 78 lb. on account of the age and type of the boiler. When this was made known to the owner, the boiler was given to an insurance company; this company allowed 90 pounds.

LESTER A. FITTS.

West Fitchburg, Mass.

Governor Troubles

The governor of an automatic slide-valve engine went to pieces suddenly. The fragments of the weight arm severely injured the engineer, smashed the switchboard and damaged the building.

The design of the governor was blamed for the accident and a new one with lighter parts was installed. When the engine was started up the new governor seemed unable to handle the valve, as it moved the valve gear in jerks even after the spring was adjusted for the proper speed.

I took the valve gear apart and found that the yoke, Fig. 1, which connects the valve rod and valve had not been fitted to hold the valve horizontal and parallel to its seat. It was, therefore, binding

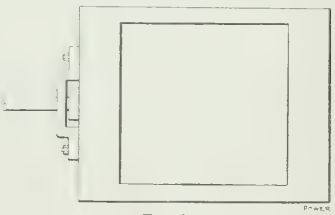


FIG. 1.

between the seat and the pressure plate and also on the top and bottom. I fitted the yoke so that the valve could move freely, and the governor gave satisfactory regulation.

Another engine showed similar symptoms in regard to valve motion and it was found that the reinforcing rib running through the center of the head-end steam ports was cracked and had risen about $\frac{1}{100}$ inch above the surface of the valve seat. The valve would strike

the projection, making it impossible to run smoothly.

As the cylinder barrel was strong and the steam chest and cover heavy enough to make the cylinder safe, I drilled a ¾-inch hole into the crack, as shown in Fig. 2, screwed in a stud about 1¼ inches long and surfaced 1 inch of the valve seat with file and scraper. The engine is now running without signs of trouble and uses less steam than before.

In another case the engine showed an inclination to race, and during such a

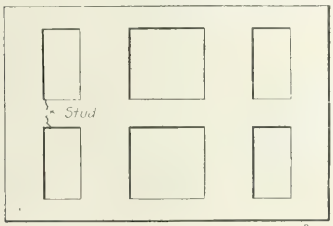


FIG. 2.

spell snapped the eccentric rod. When the eccentric straps were removed and examined it showed that they had a rib cast in to hold the babbitt, as shown in Fig. 3. After the babbitt had worn down to the rough cast iron, the straps began to bind and cut the eccentric, which was moved back, giving more steam and causing racing. When the engine attained an excessive speed the governor weight flew

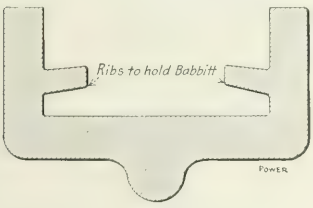


FIG. 3.

out with a jerk, throwing the eccentric forward and snapping the rod.

A similar accident happened in another case when the eccentric had become dry and began to cut.

A four-valve engine would race when running light and would slow down to a stop when the load was thrown on. The engineer blamed the governor, which was worn badly. A machinist took all the parts to the shop, where all links and pins were refitted and relined. I was sent to reassemble the governor and try it. There was no load and the engine began to race with the governor set far below its normal speed. The owner of the plant, seconded by the engineer, claimed that the governor was not assembled right, due to some parts being marked wrong when the governor was taken apart. I was quite sure about my work and, noticing that the engine would not start from the crank end, charged that somebody had been tampering with the valves. I had no indicator with me and therefore removed the valve bonnets and found that the head-end steam valve was turned upside down. The trouble was now explained; the engine always had full steam at the head end, which was enough to send it flying without load and with but little power from the crank end, as there must have been considerable back pressure before, and a decided drop in the steam line after the head-end exhaust valve gave full opening; that exhaust was also late. The valves were properly set and the governor performed well. There had been a change of engineers.

Irregularities in speed of an automatic engine are not always caused by faults of the governor and it is well to examine the valve gear and valves.

H. WERNER.

Chicago, Ill.

Shaft Hoisting Wrinkle

I had a 12-foot length of 4 7/16-inch shaft with two 5-foot pulleys on it, weighing in all about 1200 pounds, to put up in one piece. As suitable tackle had been sent but miscarried, the job was done as shown in the sketch. It was a new multiplied-strength application of an old idea and is much superior to the old roll-up on a single run of rope.

As can readily be seen, by turning the shaft *A* by means of its pulleys *F* and pulling hard at rope ends *B* the shaft was easily raised, as the takeup was cared for by the leads *E*.

Having the shaft *D* free to revolve, and occasionally striking the rope leads *E* with the hand to help equalize the strain between them helped considerably.

CHARLES HERRMAN.

New York City.

"Ammetering" an Air Compressor

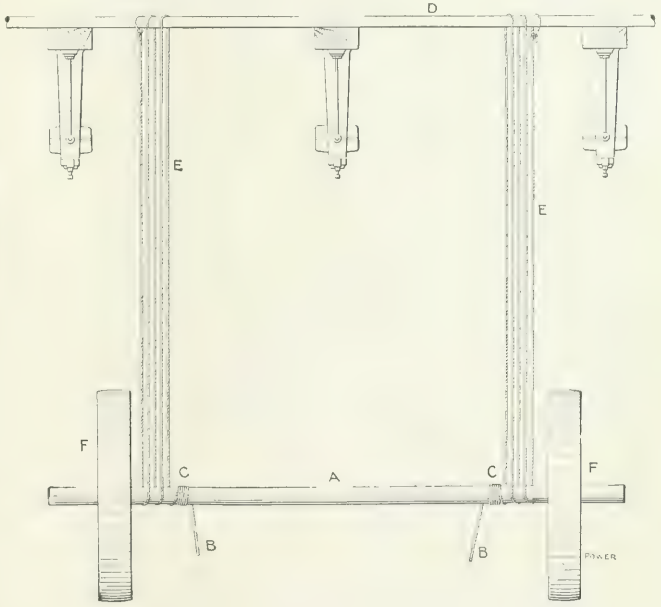
The compressor in question was a two-cylinder, double-acting machine, belt-driven from a motor. A controlling device held the suction valves open when normal pressure was reached in the receiver.

The average horsepower consumed by the machine had been determined by wattmeter readings extending over a period of two weeks. The object in applying an ammeter to the motor was to determine the power used when running idle and under load. The interesting part of the application was that the power required when running idle was 20 horsepower where it should have been around 7 or 8 horsepower.

An investigation showed that the controlling device was not working on one cylinder and that this cylinder was working steadily all day; as a result, the other was having a rest most of the time. A few minutes' adjustment had the controlling device back on the job. All of which goes to show that a little experimenting often leads to unexpected results.

JOHN BAILEY.

Milwaukee, Wis.



HOISTING SHAFT BY MEANS OF SEVERAL TURNS OF ROPE

The Scotch Marine Boiler

There appear from time to time discussions on boiler construction, mainly referring to the riveting, bracing and style of joint to be used, thereby giving the impression that these are the main features to be looked into when purchasing boilers.

Many engineers and owners think the return-tubular boiler is the only type that should be installed. I think this opinion is mainly due to lack of knowledge of other types.

I have had a number of years' experience with the return-tubular boiler and have concluded it is the least really improved type of boiler in general use, everything considered.

Safety is the most important of all points to be considered, and this is the weakest point in the return-tubular boiler. Why is it more liable to explosion and other troubles than other types? Because the most important part of the boiler (the outside), being of large diameter, is subject to excessive heat, caused by the collection of impurities between steel and water and extreme changes of temperature. Then, consider the minor faults. The blowoff pipe must be covered or it is very dangerous and when covered is not always easy to examine. The water column usually is too far from the boiler and has too many bends. I have seen the lower pipe as long as 75 inches.

It takes too long to cool a return-tubular boiler, as it has so much brickwork around it.

While I have never given the different types a test for circulation, I have decided that the return-tubular boiler has the poorest circulation of the boilers in general use. This is due to the even distribution of the applied heat.

While I am not an agent of any boiler-making firm, I am a strong advocate of the Scotch marine, internally fired boiler for stationary use. If engineers and owners would study boilers more and the steam-engine indicator and the condenser less, I think it would be time well spent.

The Scotch marine boiler is built upon scientific principles and designed to suit requirements. It is not subjected to violent explosions as the inside parts are the weaker and show signs of distress first. If anything should give way, the result would not be of a disastrous nature. Some authorities claim that this type has a poor circulation. It cannot have a poorer circulation than the return-tubular boiler, as the heat is so evenly distributed to the water.

A representative of a return-tubular boiler-manufacturing company advised me never to recommend a Scotch marine boiler to prospective buyers, his excuse being, "They are fierce when they get dirty." Is not any boiler fierce when it gets dirty?

For economy the Scotch marine heads the list when properly handled, especially in long runs. The water and steel are all that have to be heated. The loss of heat is only up the stack, if the boiler is insulated properly. The cost of upkeep should be low as this type of boiler is simple, convenient and has few parts to give trouble. It does not require over four to six hours to cool sufficiently for it to be comfortable to work inside, and it does not occupy nearly as much space per unit of capacity as other types. They have no large, hot combustion chamber to be cleaned on hot summer days.

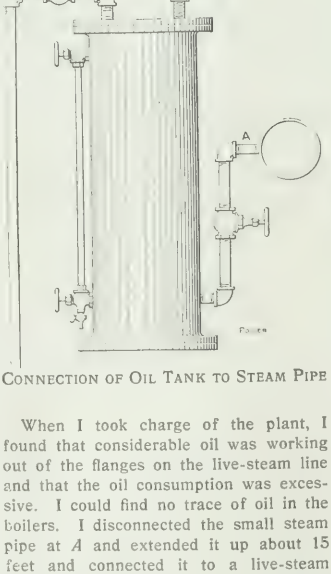
I consider an investment in a good internally fired Scotch marine boiler a good dividend payer.

RAY GILBERT.

Virginville, W. Va.

Oil in Steam Pipe

The accompanying sketch shows the connections to the tank of an oiling system. The tank is located on the rear of the boiler setting and connected to the lubricators on the engines, which were about 6 feet lower than the oil-supply tank.



CONNECTION OF OIL TANK TO STEAM PIPE

When I took charge of the plant, I found that considerable oil was working out of the flanges on the live-steam line and that the oil consumption was excessive. I could find no trace of oil in the boilers. I disconnected the small steam pipe at *A* and extended it up about 15 feet and connected it to a live-steam line on the floor above. It was a direct and independent line from the main header over the boilers. This stopped the trouble, but how did the oil get into the live-steam line?

G. A. ROBERTSON.

Louisville, Ky.

Piston Trouble

In the equipment of a steam power plant there are two 31 and 66 by 48-in. cross-compound engines running at 90 revolutions, each directly connected to 1500-kw. generators.

The high- and low-pressure cylinders both have tail roads and floating pistons. As shipped by the makers, the pistons

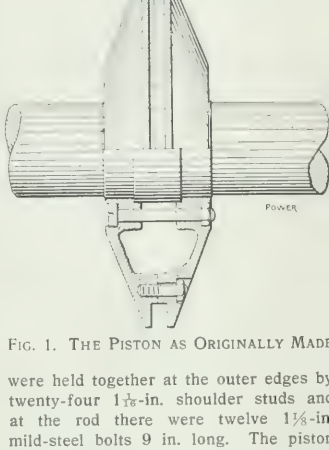


FIG. 1. THE PISTON AS ORIGINALLY MADE

were held together at the outer edges by twenty-four 1⅛-in. shoulder studs and at the rod there were twelve 1⅛-in. mild-steel bolts 9 in. long. The piston was counterbored on both sides to receive the heads and nuts of these bolts, the construction being shown in Fig. 1.

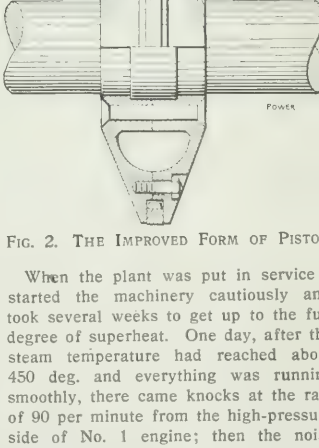


FIG. 2. THE IMPROVED FORM OF PISTON

When the plant was put in service started the machinery cautiously and took several weeks to get up to the full degree of superheat. One day, after the steam temperature had reached about 450 deg. and everything was running smoothly, there came knocks at the rate of 90 per minute from the high-pressure side of No. 1 engine; then the noise stopped as suddenly as it had begun. Another unit was put into service and a hunt for the cause of the trouble began. External examination showed a bad twisted exhaust-valve stem, and when the cylinder head was taken off the cau

was plain. A follower bolt had snapped off in the threads and while the nut was being hammered between the piston and the cylinder head the bolt had been swept into the exhaust port and caught by the valve as it started to close. Something like a dozen blows had been struck, and it spoke volumes for the workmanship of the engine that it could be used as a steam hammer without serious injury.

The nut and bolt were found in the receiver, but in such a shape that I could tell nothing about the cause of the break, so I assumed it to be a case of poor material and replaced it with a Norway iron bolt.

Shortly afterward another one broke, and I replaced them all with Norway iron. Then one of the Norway bolts went and I decided that it was the concentration of the stress at the root of the threads that was doing the damage and I had all of the bolts turned down to ⅞ in. for a space of 3½ in. at the middle.

Then some more broke and I was forced into the conclusion that there must be an unusual and unallowed-for stress in those bolts and began to hunt for it. From the shape of the halves of the piston it appeared to me that the temperature changes which would take place between 70 and 450 deg. would cause a distortion sufficient to stress the bolts beyond the elastic limit. The matter was taken up along these lines with the manufacturers, who furnished two new pistons in which the 1⅛-in. bolts were replaced by 1½-in. rivets. Both these features added wonderfully to the rigidity of the construction and there has been no return of the trouble. The piston as replaced is shown in Fig. 2.

LINDSAY DUNCAN.

McGill, Nev.

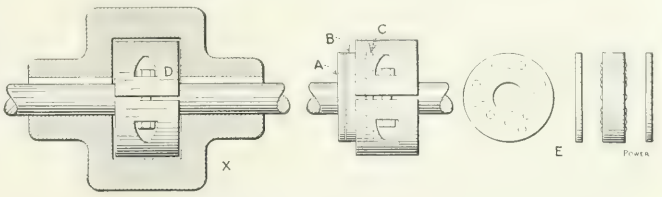
Ball Bearing Thrust Collar Eliminated Heating Trouble

A thrust collar which gave considerable trouble by heating was employed on the shaft of a motor and turbine pump, which ran at a speed of 1800 revolutions per minute.

Sulphur, graphite, castor oil and various grades of lubricating oil were used, but none of them prevented the heating. Finally it was determined to try to insert a ball-bearing thrust collar.

The collar was removed from the recess in the bearing, placed in the lathe and countersunk a depth equal to one-half the thickness of the ball-bearing thrust collars, as shown at *B* and *C*. It was then only necessary to cut enough away from the thrust end of the box to admit a thin steel ring plus half the thickness of the thrust collars which were placed on the shaft, as shown at *A* and *B*. The cap was treated in like manner.

The steel rings *A C* and the ball-bearing ring *B* are solid. After removing the shaft part way out of the bearing, they were put in place, as shown at *X*. The split thrust collar *D* was then put in place, as shown. This was an easy matter, since the countersink was a trifle larger than the diameter of the rings.



THRUST COLLAR FOR BALL BEARING

Upon testing the job it was found that the shaft could be rotated by one hand, whereas before making the change it was about all a man could do to turn the shaft by means of the coupling. When the motor was started no further heating occurred, the bearing remaining practically cold after a prolonged run. The two rings and ball-bearing plate and placing of the 20 balls are shown at *E*.

WILLIAM KAVANAGH.

New York City.

Home Made Damper Regulator

Will some of the readers of POWER tell me how to make a damper regulator at a small cost and without going to a machine shop, illustrated with drawings, if possible?

A. SEIMES.

Atlantic City, N. J.

Cause of Boiler Explosions

Most any steam engineer knows that when getting up steam he should always open a valve connected to the boiler to let the cold air escape.

I have seen three boiler explosion and none had been freed of air. The first was a portable boiler. The engineer was getting up steam ready to start at 7 a.m., and the glass was half full of water which ran freely out of the second try cock. Steam was raised very slowly and the gage showed about 40 pounds pressure when the engineer opened the steam valve on the injector. A little air came first, followed by steam, and almost at the same time the boiler exploded.

The second explosion was that of a boiler in a small mill. No valve had been opened until the engineer opened the throttle to warm up the engine, when there was an explosion which killed one man.

The third explosion happened to one of a battery of eight boilers. The boilers were all shut down and washed out. The two small boilers were filled with cold water and a fire started under them about 9 a.m., to get up steam for the pumps and machine shop. About 1:30 p.m. there was enough steam to start one of the pumps to fill a tank, but as soon as the pump was started, both ends of No. 8 boiler blew out, killing two men and wrecking things in general.

I have been engineering for 15 years, both marine and stationary, and I have come to the conclusion that not one boiler in 20 blows up because of low water.

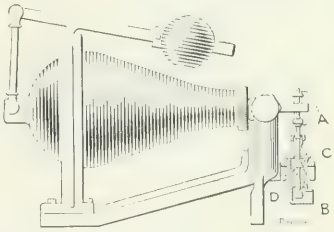
D. M. FRASER.

Wallaceburg, Ont., Can.

Springs on Trap Valve Stem

Having had some trouble with a large return trap, due to the release-valve stem breaking, I adopted a scheme which has entirely eliminated the trouble.

The action of the trap on filling is to force the valve *B* against its seat and on discharging the valve *C* was forced against its seat. If the nuts *A* were not exactly adjusted, either an unnecessary strain was put on the valves or they did not seat properly. Sometimes the stem would break at *D*.



SPRINGS ON TRAP-VALVE STEM

To overcome the trouble two small springs were wound and placed between the lever on the bowl and the two adjusting nuts *A*. This allowed the valves to cushion easily and after 18 months' service the trap has not once required attention.

GEORGE H. HANDLEY.

Newburgh, N. Y.

Rendered necessary by the growth of the demand for electricity from the municipal plants, the authorities in Birmingham, England, will erect an additional central station to cost about $1,216,625.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Dry Back Marine Boiler

In POWER for October 31, Mr. Fenwick makes inquiry as to the suitability of the internally fired or Scotch boiler as adapted to stationary use, for continuous service of about three months, and also as to the sizes in which the units are built.

Answering the last question first, this type of boiler is made in any size from 75 to 300 horsepower or even larger, and for all pressures up to 175 or 200 pounds, with one, two or three furnaces, depending on the size.

As to their suitability for a three-months continuous run, local conditions will govern that, as it depends almost entirely on the quality of the feed water and the temperature at which it enters the boiler.

If the water does not contain any great amount of scale-forming materials and is heated to 200 degrees Fahrenheit or better, Mr. Fenwick should not experience any difficulty in operating such a boiler under reasonable conditions for three months, or even longer, and by using the blowoff about three or four times a day for a few seconds, preferably when the load is nearly or all off, considerable of the impurities can be removed.

If the water is very bad, his best way would be to install a live-steam purifier (with an auxiliary open heater), which can be cut out and cleaned in half a day at any time during the run.

If these boilers are fed near the top with comparatively cold water, the circulation is poor. The feed water should enter the top of the boiler, pass down between the furnaces at the front end (or beside it if only one furnace is used) and discharge into the bottom of the boiler with the pipe looking toward the back head and about a foot from the bottom. See that the feed pipe is well braced inside the boiler.

The dry-back Scotch boiler is quite common in stationary practice generally and is very satisfactory, all things considered. It is self-contained, easily cleaned and will stand considerable forcing if necessary. The water column should be connected up with good liberal piping, the crosses plugged with brass plugs instead of elbows to facilitate cleaning.

Cover the boilers with at least 2 inches of good magnesia covering and it will stay on the job as long as any boiler made, without cleaning.

GEORGE H. WALLACE.

Racine, Wis.

Charles Fenwick, in a recent issue, asks whether the internally fired, dry-back type of marine boiler, commonly called "Scotch" boiler, gives much trouble due to poor circulation.

With boilers of this type it is common practice to use a pump to circulate the water in the boiler when getting up steam and on some boats the pump is run continuously.

The writer has operated boilers of this type and found no trouble from this cause when the feed water is piped into the boilers as shown in the two views of Fig. 1.

WILLIAM E. FRANCIS.

Lynn, Mass.

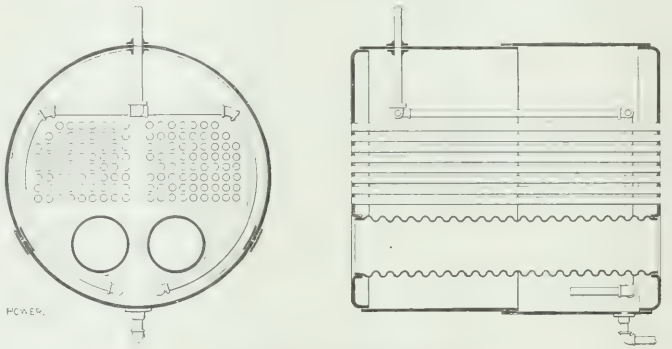


FIG. 1. FEED-PIPE ARRANGEMENT

In reply to Mr. Fenwick's inquiry in the October 31 issue, I would say that the dry-back marine boiler, or the continental boiler, as it is better known, is extensively used in small plants. It gives good service, especially on long continuous runs. The principal trouble experienced with this type is poor circulation. This may be overcome to a large extent by the simple piping arrangement shown in the sectional view, Fig. 2. The piping shown is extensively used in marine work for overcoming poor circulation.

A still better arrangement is to have the boiler-feed pump so connected that when required it will pump the water from the lower part of the boiler into the upper part, thus forcing the circulation. The circulation is, of course, the worst when first starting up. It is at this time that the pump is most useful. As soon as enough pressure has been developed the pump is started and by thus mechanically circulating the water conditions are greatly improved.

A boiler with a corrugated furnace flue should be selected by all means as the straight flue is more prone to develop leaks. The boiler should be covered with a thick coat of some good insulating material, not only because greater efficiency will be obtained but also because trouble with leaking girth seams will be minimized. With a good covering, the expansion and contraction strains are reduced because both sides of the shell are kept at a more nearly equal temperature.

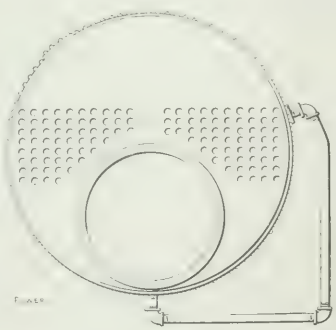


FIG. 2. ARRANGEMENT FOR IMPROVING CIRCULATION

This type of boiler will stand much hard work if properly handled and it is capable of producing excellent results.

C. R. MCGAHEY.

Baltimore, Md.

Unequal Port Opening

In the November 14 number, Mr. Mueller states that he cannot get equal port openings of the valve on a traction engine. Before trying to make the port openings equal, Mr. Mueller should make sure that the design of the engine will permit of this being done without disturbing the equality of the points of cutoff.

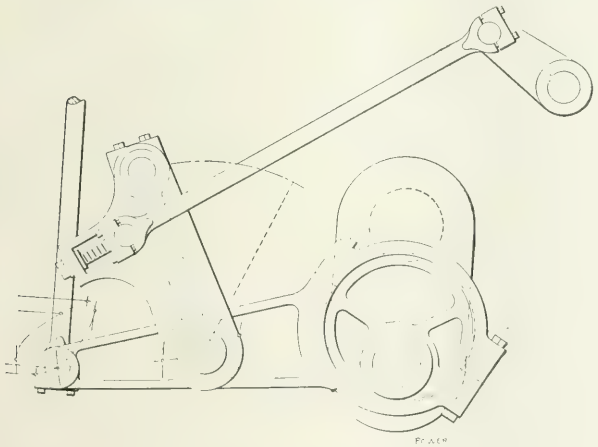
I operate a Case traction engine and the valve on this engine has a $\frac{3}{32}$-inch lead at the crank end and no lead at the other. I know another make of engine which requires a $\frac{1}{16}$-inch lead at one end and a $\frac{5}{16}$-inch at the other.

Some good traction engineers pay no attention to lead whatever when setting the valves. They go entirely by the point of cutoff.

P. C. FORGARD.

Lake Preston, S. D.

Referring to Mr. Mueller's inquiry in the Nov. 14 issue, I will say that while I was serving aboard the U. S. cruiser "Chicago," I had an opportunity to become familiar with the valve-gear of the main engines. This gear was of the See Marshall radial design. The gear is designed to give more power on the upstroke so as to compensate for the weight of the reciprocating parts. No doubt



THE SEE MARSHALL RADIAL VALVE GEAR

the gear on Mr. Mueller's engine was laid out with the same end in view.

CHARLES W. ROOS.

New York City.

I have given the diagram shown by Mr. Mueller in the Nov. 14 issue some study and I do not see why, if all parts have been replaced and any new parts that may have been made were made the same as the old parts, the valve travel should not be correct.

This is the Hackworth gear and it is very simple in design. The link pivot should be on a straight line with the center line of the main shaft, and a distance from the center of the shaft equal to the distance from the center of the eccentric to the center of the link-block pin. If the point where the valve stem connects to the eccentric is correctly located, the reverse lever may be thrown from full gear ahead to full gear back and not move the valve at all in either direction. If adjustments are made so that these conditions are obtained the gear is correctly set.

If the lead is made equal on both ends, the cutoff cannot take place at the same point in both strokes on account of the angularity of the connecting-rod, which is greater with a short rod. I think the valve motion was designed to give equal steam distribution and, if the adjustments are correctly made, no trouble will be experienced with the running of the engine as the difference in port opening was made so as to overcome the difference caused by the angularity of the rod.

ERNEST BRONG.

Mt. Vernon, Ohio.

Centrifugal Pump Speed

N. C. Hurst, in POWER for Nov. 14, on page 751, in criticizing an article by T. W. Holloway in a preceding issue, states that a mathematical analysis will show that the rim velocity of a centrifugal pump runner working against a head h should be theoretically $\sqrt{gh}$, not $\sqrt{2gh}$.

The centrifugal force acting on a body whose weight in pounds is W, linear velocity $= v$ feet per second, at radius r in feet is

$$F = \frac{W}{g}\frac{v^2}{r} = \frac{W}{r}\frac{v^2}{g}$$

Now Mr. Hurst says that if $W = 1$ and $r = 1$, $F = \frac{v^2}{g}$, which is true. But why restrict the formula to those values? It is just as true for any other values of W and r. If W and r are given such values that $W \div r = 1 \div 2$, or so that $W \div r = 3$, one could write

$$F = \frac{v^2}{2g}, \text{ or } F = \frac{3v^2}{g}, \text{ etc.}$$

The flaw in the argument is that he says that this force F is equal to the head h. In other words, a force of, say, 10 lb. is equal to 10 ft. of water. In order to bring in the relation between the two a pressure must be had in terms of unit area, for 2.3 ft. of water equals 1 lb. per square inch. In order to get this relation a definite amount of the water must be considered in order to get this centrifugal force per unit area.

Consider a small elementary prism of water extending from the axis of rotation to the outer rim of the runner, whose cross-section area is A and whose length is r; a volume of Ar is obtained. If p = pressure in pounds per square foot and w = weight of 1 cu.ft. of water, one may write

$$W = wAr, \text{ and the mass} = \frac{wAr}{g}$$

Now the acceleration must be the acceleration of the mass center which is at a distance of $r \div 2$ from the axis. Hence for the square of the velocity divided by the radius must be written

$$\text{Acceleration} = \frac{\frac{v^2}{4}}{\frac{r}{2}} = \frac{v^2}{2r}$$

Thus

$$F = \frac{wAr}{g}\frac{v^2}{2r} = \frac{wAv^2}{2g}$$

But

$$F = p_1 A - p_0 A$$

where

p_1 = Pressure at radius r;
p_0 = Pressure at center.

Therefore,

$$p_1 - p_0 = \frac{wv^2}{2g}, \text{ or } \frac{p_1}{w} - \frac{p_0}{w} = \frac{v^2}{2g}$$

But since $p \div w$ = pounds per square foot $\div$ weight of 1 cu.ft. of water which equals a head in feet of water,

$$h = \frac{p_1}{w} - \frac{p_0}{w}$$

Therefore,

$$h = \frac{v^2}{2g}$$

An actual centrifugal pump depends for its action upon other forces than centrifugal forces, though the latter is an important factor. Therefore, the above holds true only for the case where no flow is taking place, for then only are investigators concerned with centrifugal forces alone. As soon as flow takes place, other factors come in, and it is possible to get a head greater than the centrifugal head alone. However, some pumps have a falling characteristic so that the head continually decreases as

the flow increases. The other type of pump gives an increase in head for small values of discharge and then the head decreases again, and for the conditions where the pump gives its best efficiency the head is usually less than the shutoff pressure.

A complete theory of centrifugal pumps which considers all factors will show that if no flow takes place a centrifugal head of $\frac{v^2}{2g}$ is had, and other items will give a maximum head input of

$$\frac{v^2}{g} = 2\frac{v^2}{2g}$$

But complete theory will show likewise that there is a loss of $\frac{v^2}{2g}$, so that the theoretical head output is the centrifugal head

$$h = \frac{v^2}{2g}$$

as stated by Mr. Holloway. A good treatment of this subject will be found in L. M. Hoskins' "Hydraulics." It is too long to give here.

Therefore, both by theory and practice, the shutoff head of a centrifugal pump will be very nearly

$$h = \frac{v^2}{2g}$$

When the pump is actually delivering water at about its best efficiency the head is usually somewhat less than this.

R. L. DAUGHERTY.

Ithaca, N. Y.

Float Pump Control

The device described by C. S. Runion in the Nov. 7 issue is neat and effective looking. There is one point which I think might improve the sensitiveness of the control, and that is to replace the beam center bearing and journal with a case-hardened steel knife edge and surface. The impromptu roller bearing described might quite easily get jammed or otherwise "stuck up" at a critical moment and possibly with critical results.

JOHN S. LEESE.

Manchester, Eng.

A Vacuum Puzzle

In the plant where I am employed there is a 500-horsepower Corliss compound engine driving automatic looms, a work which requires the best of speed regulation. A short while ago a small high-speed engine was installed beside it to help out with the lights, and it exhausts into the same condenser, which is of ample size for both engines. I looked for no trouble, but found on starting the small engine that the vacuum was reduced from 27 to 24 or 25 inches and that the Corliss speeded up. I made no changes at first, thinking that I must be mistaken in regard to the increase in speed, but in less than a week the complaints were made that as soon as the lights were put on the speed became too high.

Now if the speed had slackened ½ turn with the lower vacuum, I should not have been surprised; neither would I if it had remained the same as before, but to have a higher speed with all conditions the same except a lower vacuum is a puzzle to me.

LEIGHTON JOHNSON.

Exeter, N. H.

Feed Water Regulators

In an editorial in the November 14 issue the question is asked, "What is the use of a feed-water regulator?" Ninety men out of one hundred would say, "To keep the water level constant." Well, what is the use of keeping the water level constant? So long as the water is not allowed to get so low as to endanger the heating surface nor so high as to be carried over with the steam, what difference does it make if the water level does vary an inch or two?

To my mind, this question answers itself, for if the water level is constant it will never get so low as to endanger the heating surfaces nor so high as to be carried over with the steam, and this is a point in favor of feed-water regulators. The editorial also states that a feed-water regulator is either always wide open or entirely closed and is alternating in its action, and the editor aims to substantiate this theory by citing a single boiler equipped with a feed-water regulator and saying that with a 100-horsepower boiler with a water surface of 90 square feet evaporating at its rated capacity, 30,000 pounds of water per hour with a boiler-feed capacity of 60,000 pounds per hour the regulator would be closed just one-half the time, at periods from four to eight minutes, according to the nicety of adjustment, and offers this as a very objectionable feature owing to the change of temperature of feed water between periods.

With a single boiler this is true but the editor seems to overlook the fact that most plants which use feed-water regulators are those having several boilers operating in batteries, and it is a well known fact that boilers working in batteries, even though they are of the same size and exactly alike, will not evaporate the same amount of water per hour. Take, for instance, three 100-horsepower boilers; place them in a battery and probably one will be evaporating 30,000 pounds, its rated capacity, and the one on its right may be evaporating only 20,000 pounds, while the one on its left may be evaporating 40,000 pounds, which is above its rated capacity; and probably in 20 minutes these conditions may be reversed.

It has been my experience with feed-water regulators when working on boilers in batteries that the demand for feed water was about constant and in proportion to the combined evaporative capacity of the battery; the feed pumps ran at uniform constant speed and the feed-water temperature was about constant.

H. R. ROCKWELL.

Alton, Ill.

Air Lift Calculations

In the Nov. 21 issue the answer given to the questions by J. A. W. is open to discussion. In the first place, the answer assumes that there is a difference between the pumping and the starting levels of the water in the well. I do not think that there is any ground for such an assumption. I have seen many wells from which 200 gal. per minute could be pumped without lowering the level of the water.

It is generally assumed that a submergence of 60 per cent. is desirable. Such being the case, 130 ft. or the lift equals 40 per cent. Then, the length of pipe to be submerged will be

$$130 \times 1.5 = 195 \text{ ft.}$$

and the required pressure will be

$$195 \times 0.43 = 84.6 \text{ lb. per sq.in.}$$

and, adding 3 lb. for friction, the actual working pressure will be 87.6 lb. per square inch.

The answer further states that a 3½-in. pipe would be of satisfactory size for the water pipe. According to the best air-lift practice, this seems rather small. A 4-in. pipe would be better.

S. L. HILLS.

St. Louis, Mo.

Pipe Bends

I was much interested in the editorial in the Dec. 5 issue on "Pipe Bends," but it seems to me that there has been omitted one of the most important features and uses of pipe bends. All steam lines expand more or less under the increased temperature due to the steam, and in the long lines the expansion is an item of considerable importance. With the use of the ordinary fittings for making bends on lines of this character, there is always a danger of fracture of the bends. The use of the long-turn bends as a method for taking up this expansion and transmitting it with the least possible strain forms part of the value of such bends; and in many cases, through the use of loops made of these bends, expansion joints can be entirely avoided with safety, thus eliminating the annoyance often given by joints of this character.

I have found in power plants installed by myself and associates that it pays, as the editorial stated, to use pipe bends; the results in the operation of the plant have been much more successful, there have been far fewer leaks, bad joints and breakages, and the cost has been no greater.

HENRY D. JACKSON.

Boston, Mass.

Inquiries of General Interest

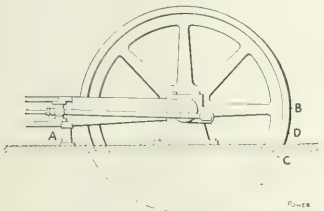
Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

To Find the Dead Center

How is the exact dead center of an engine to be found?

R. W.

Turn the crank just past the center and mark the crosshead and guide, *A*. Also measure from the floor (about 18 in.) to the side of the flywheel rim and make a center punch-mark, *B*. Now turn the crank the other way past the center



PUTTING AN ENGINE ON DEAD CENTER

to bring the marks on the crosshead and guide line in line; then make another mark on the flywheel rim the same distance from the first *C*. Make a permanent center punch-mark on the flywheel rim halfway between the marks on the rim, *D*. If the flywheel is turned until the permanent center punch-mark is the same height from the floor, or 18 in., the engine will be on the exact center.

Horsepower of Compound Engine

How do I find the horsepower of a compound engine?

A. P.

Divide the mean effective pressure in the high-pressure cylinder by the cylinder ratio, add the quotient to the mean effective pressure in the low-pressure cylinder, and proceed to find the horsepower with the diameter of the low-pressure cylinder and the mean effective pressure found.

Lubricating Oil for Air Compressors

What is the best lubricant for air compressors? What are the flash or fire points of ordinary engine and cylinder oils?

J. C.

A suitable cylinder oil is of 550 deg. flash, made up of a high-grade cylinder stock with not less than 20 per cent. by weight of an acidless animal oil; tallow or tallow oil is preferable.

Cylinder oil should not show a flashing point below 525 deg. F., or a burning point below 600 deg. Fahrenheit.

Engine oil should not show a flash point below 325 deg.; it should have a specific gravity of about 29 deg. Baumé.

Steam Lost through Safety Valve

How much will it cost to blow a 3-inch pop safety valve six minutes, reducing the steam pressure from 100 to 97 pounds? Coal costs $3.50 per ton.

E. H. E.

In the Massachusetts safety-valve rules it is assumed that the rise of a 3-inch disk will be 0.09 inch. The quantity of steam that will flow through an orifice may be approximately calculated by the formula

$$W = \frac{a\,p}{70}$$

in which

W = Pounds of steam discharged per second;

a = Area of the orifice in square inches;

p = Absolute pressure in pounds per square inch.

Taking the average boiler pressure during the period of blowing as 98.5 pounds gage, the weight discharged per second will be

$$\frac{3 \times 3.14 \times 0.09 \times 113.2}{70} = 1.37$$

per second, and for six minutes it will be

$$6 \times 60 \times 1.37 = 493.2 \text{ pounds}$$

The value of the coal burned to make this amount of steam depends on the rate of evaporation. One pound of coal costs 0.175 cent. If nine pounds of water are evaporated per pound of coal burned it will cost $0.175 \times \frac{493.2}{9}$ = 9.57 cents to blow a 3-inch safety valve six minutes when one pound of coal costing $3.50 per ton evaporates nine pounds of water into steam at 98.5 pounds gage pressure.

Boiler Horsepower for Elevators

What boiler horsepower should be allowed for three hydraulic elevators, each having an area of 30 sq.ft. and a speed of 400 ft. per minute?

G. L. P.

To determine the boiler horsepower required depends on the load the elevators will carry, the weight of the elevator minus the counter-balance, the speed and the efficiency. Assume 80 lb. live load per square foot, the weight of the car as 3600 lb., the counterweight as three-quarters of the weight of the car, and the efficiency as 60 per cent. Add the weight of the live load to the unbalanced weight of the car and divide the sum by the product of 1 hp. expressed in foot-pounds and the efficiency. The unbalanced weight of the cars will be

$$3600 \times 3 \times 0.25 = 2700 \text{ lb.}$$

The live weight will be

$$30 \times 80 \times 3 = 3600 \text{ lb.}$$

Substituting these figures in the rule the following result will be obtained for the continued upward movement at full load:

$$\frac{(7200 + 2700)\,400}{0.6 \times 33{,}000} = 200 \text{ hp.}$$

No power is required on the downward movement. The horsepower required per trip would average:

$$\frac{200}{2} = 100 \text{ hp.}$$

Allowing 30 per cent. for slower speed at stops and light loads, about 70 hp. would be required. If a compound pump was used, taking 65 lb. of steam per hour per delivered horsepower, the total steam consumption per hour would be

$$70 \times 65 = 4550 \text{ lb.}$$

Water for Manufacturing Ice

Why is it necessary to use distilled water in manufacturing can ice and ordinary water in manufacturing plate ice?

K. H.

In making can ice the water to be frozen is placed in rectangular cans and is immersed in a refrigerating medium. Freezing takes place on the sides and bottom of the can and the ice increases in thickness until all the water in the can solidifies. Any impurity in the water is driven toward the upper center of the can and is frozen in; hence the necessity of pure water. In making plate ice the water is frozen on both sides of a hollow or cellular metal plate immersed in a tank of ordinary potable water; any impurity is thrown out and settles in the bottom of the tank. The tank can be cleaned by draining off the water. The refrigerant is circulated through the interior of the plate.

Fatal Accident at Chicago

On Dec. 23, at the factory of the Chicago Malleable Castings Co., at Chicago, Ill., the blowoff valve of a 400-hp. vertical water-tube boiler was blown free from its connections, and the escaping steam fatally scalded the fireman and severely injured the engineer. Just before the accident the engineer had opened the valve to blow down the boiler with the fireman standing a few feet away. For some unknown reason the force of the steam blew off the valve and both men were scalded before they could move away. The fireman died the following morning, and the engineer is thought to be out of danger, though at the last report he was still under treatment at the hospital.

Fire from Burst Pipe at Georgetown, Ky.

By the bursting of an ammonia pipe on Dec. 24, the wax plant of the Indian Refining Co., at Georgetown, Ky., was destroyed by fire, resulting in a loss of $125,000.

Tanks of oil and all the machinery in the plant were also destroyed by the fire, which burned for three hours before it was brought under control. Two employees were injured by falling timbers.

BOOKS RECEIVED

QUALITATIVE ANALYSIS; A BRIEF LABORATORY GUIDE. By Arthur E. Hill. Chemical Publishing Co., Easton, Penn. Cloth; 80 pages, 5¼x7 in.; indexed. Price, $1.

PORTLAND CEMENT. By Richard K. Meade. Chemical Publishing Co., Easton, Penn. Second edition. Cloth; 501 pages, 6x9 in.; illustrated; tables; index. Price, $4.50.

NEW PUBLICATION

TESTING OF ENGINES, BOILERS AND AUXILIARY MACHINERY; second edition. By W. W. F. Pullen. Published by the Scientific Publishing Co., Manchester, England. Cloth; 721 pages, 8½x5½ in. Price, 12 shillings 6 pence.

The testing of boilers, engines and other power-plant accessories is treated in a general way, the object being to acquaint the reader with the methods used and the proper handling of the instruments to be employed, so that these may be adapted to meet the needs of each particular case. The theories underlying the operation of many of the instruments are also given.

Since the old steam tables of Regnault are still used in many quarters, they have been included, while curves plotted from the more recent steam tables of Marks and Davis are added for optional use. In point of criticism it may be noted, however, that these curves, as well as the entropy charts given in the appendix, are much too small for accurate work.

In spite of the fact that some devices of more or less recent date but of general use in American practice are omitted, the subject is well covered and should prove a handy reference book to the engineer who is called upon to test power-plant apparatus.

OBITUARY

John George Ould died at his home, 1348 Forty-seventh St., Brooklyn, N. Y., on Dec. 21. Mr. Ould had been in poor health for some time. His last appearance was at the annual meeting of the American Society of Mechanical Engineers.

Mr. Ould was born on Apr. 2, 1863, in Falmouth, England. He was graduated

JOHN G. OULD

from the private schools in England and later took a three years' course in the Kensington Science and Art School. He also took a two-year course in the New York Y. M. C. A., two years in Pratt Institute and three years in the Polytechnic Institution of Brooklyn, and had a diploma from the I. C. S. as an electrical engineer.

In his youth he was an apprentice in English shops and then served seven years as a marine engineer on ocean-going vessels. Mr. Ould came to New York in 1890, and for some time was a chief engineer. For 14 years he was superintendent and chief engineer of the Polhemus Memorial Clinic, Brooklyn, N. Y., taking that position in February, 1897.

Mr. Ould was a member of the Philharmonic Society of Brooklyn, an associate member of the American Society of Mechanical Engineers and a corporate member of the Brooklyn Engineers Club. At the time of his death he was a vice-president and commissioner of apprentice training of the Institute of Operating Engineers, as well as being a charter member of the latter.

Mr. Ould was a man of the highest merit in his public and private life and impressed his personality upon everyone he met. He leaves a widow.

Bureau of Mines Appropriations

In the general estimates for appropriations for the fiscal year 1912, which begins July 1, Secretary of the Interior Fisher has recommended the following items for the Bureau of Mines:

For the investigation as to the causes of mine explosions, methods of mining and safety of miners, the appliances best adapted to prevent accidents, the possible improvement of conditions under which mining is carried on, the use of explosives and electricity, the prevention of accidents, and other inquiries and technologic investigations pertinent to the mining industry, $360,000.

For the investigation, analyzing and testing of coals, lignites, etc., belonging to or for the use of the United States, $135,000.

For investigations into the treatment of ores and other mineral substances, with special reference to the prevention of waste in the mining and utilization of important mineral resources, $100,000.

For the investigations of Alaskan coal, with reference to its mining, transportation and utilization, $50,000.

PERSONAL

W. H. McIntyre, formerly fourth vice-president of the Equitable Life Assurance Company, is now first vice-president and general manager of Manning, Maxwell & Moore, Inc., New York City.

For the practice of mechanical and electrical engineering, George C. Thornton and Richard W. Alger, of Chattanooga, Tenn., have formed a partnership in that city. Particular attention will be given to heating and ventilation, plumbing and sanitation and the lighting of modern buildings.

Some time since, Prof. Edward F. Miller, of the Massachusetts Institute of Technology, commented upon the desirability of a temperature entropy chart upon a large scale for classroom use. He was agreeably surprised the other morning by finding upon the wall of the lecture room such a chart, 6 ft. in height by 10 ft. in length, the handiwork of Erwin Haskell Schell, of the class of 1912.

POWER

Vol. 35 NEW YORK, JANUARY 9, 1912 No. 2

Old joke No. 53, series K: "A camel can go eight days without taking a drink. But who wants to be a camel!"

Variation: Most engineers are good fellows. But who wants to be an engineer!

You may take it from one who knows, the engineers, by and large, are the hardest-worked and least-appreciated class of men.

This is due entirely to ignorance—some ignorance on the part of the engineer himself and much ignorance on the part of the employer and the public in general.

The average employer thinks that the engineer is only a mechanic, a man who is called upon to use his muscles more often than his intelligence. He does not realize that to generate power continuously and cheaply, and to get the best work possible out of a given equipment, require a man of much education, experience and intelligence.

The general public seldom thinks of the engineer at all.

What a pretty pickle indeed all of us would be in if the engineers and firemen were suddenly unable to do a tap of work some cold morning.

To begin with, about everyone who did not own a horse or an automobile would have to walk down to work as no cars would be running.

Then, when the office was finally reached there would be a stair-climbing stunt to perform because none of the elevators would be in service.

Next, there would be no heat—without engineer and fireman, even the heating system would be useless. And with the mercury down around the freezing point this would be serious.

In the mills and factories the hands would be compelled to take a day off, for without power to run the manufacturing machinery, the workmen would be helpless.

Now, the engineer himself knows all this—it is an old, old story to him. But the public remains in blissful ignorance.

The whole trouble is this: While the importance of mechanical power has grown enormously, the public estimation or appreciation of this fact has grown hardly at all.

It is up to the engineer to educate the public concerning himself and his work. He has neglected this too long as it is. The sooner he does it, the sooner will he come into his own.

At one of its recent meetings the American Society of Mechanical Engineers came to the conclusion that the general public needs educating along all lines relating to technical matters and it has undertaken to supply the same.

GENERAL OPINION OF WHAT AN ENGINEER'S JOB CONSISTS OF . . . .
WHAT AN ENGINEER'S JOB REALLY AMOUNTS TO
WHAT THE ENGINEER SHOULD PLANT TO GROW THE CORRECT OPINION

It occurs to us that various operating engineering bodies can well take up work along similar lines.

Power System Cleveland Cliffs Iron Co.

By C. A. Tupper

General description of the power system which is now being installed for the operation of the various mines of the Cleveland Cliffs Iron Co.

The system when completed will consist of one large hydro-electric plant supplemented by two steam plants, each distributing current at 60,000 volts over an area of 40 square miles.

The Cleveland Cliffs Iron Co. is constructing a hydro-electric power system which will serve all of its mines on the Marquette range, a district in which this corporation is the largest operator. The Carp River is being harnessed and about 6000 kw. will eventually be developed. The project is the second of its kind upon which this company has embarked, the first having been on the Au Train River, and is one of the most important undertaken in upper Michigan. Much important preparatory work has been done with the installation of a large quantity of electrical machinery at the mines and shops, including motor-driven trams, hoists, pumps, compressors, tools, etc., the construction of transmission lines, and the establishment of two large central generating stations, equipped with steam turbines, which now furnish the power required and will later serve as auxiliaries to the hydro-electric plants.

Concrete Dam

The site chosen for the water-power station is a mile from the point at which the Carp River empties into Lake Superior, being located at the foot of Mt. Mesnard. The concrete dam now under construction is about four miles from the generating plant. Its spillway is 120 ft. long and 48 ft. high, and secure protection against washouts has been provided by a curved retaining wall 150 ft. long and 7 ft. wide, reënforced horizontally with old cables at the point where it joins the main spillway.

The water will be carried to the wheels in a steel and stave pipe line 21,500 ft. in length, and 60 to 66 in. in diameter, 8567 ft. being of lock-bar steel, 2233 ft. of welded steel and the remainder of wooden staves. A surge tank 16 ft. in diameter and 130 ft. high will be placed at the top of Mt. Mesnard; the available head is about 600 ft. At the power plant two 3000-kw. Allis-Chalmers hydraulic turbine units and three 1900-kilovolt-ampere transformers are being installed. The system is designed to carry 60,000 volts, but, for the present, current, will be transmitted at 30,000 volts. It is expected to have the new plant in operation early next spring.

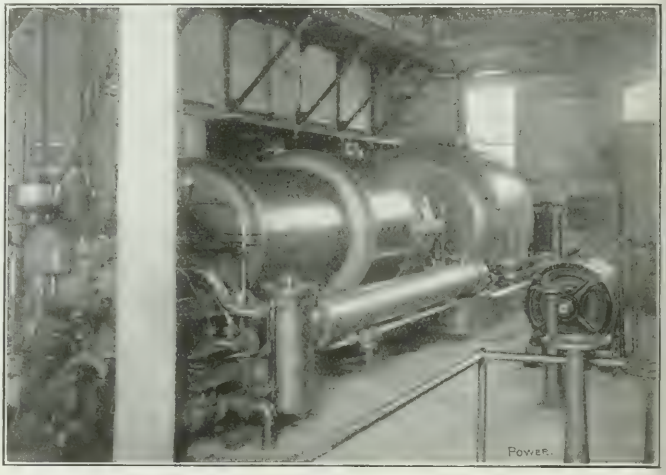


Fig. 2. 1500-kw. Turbine at Maas Mine Plant

Transmission Line

The transmission line under construction, which consists of No. 2 B. & S. solid-copper cable carried on steel towers, will connect the Mt. Mesnard power house with the auxiliary and distributing station already in service at the Maas mine, Negaunee, which is in turn connected similarly with a plant of the same kind at the Princeton mine in the Swanzy district and with the Cleveland Cliffs properties in the Ishpeming and North Lake fields. Altogether the transmission system covers a territory of 40 square miles, and there will be a double circuit over the entire line.

Fig. 1. Exterior View of Maas Mine Plant, Showing Condenser

Steam-turbine Plant

The steam-turbine plant at the Maas mine (see Fig. 1) is laid out in accordance with good engineering practice. The boiler room contains four 350-hp. Stirling boilers, with Murphy stokers, the furnace fronts being set out 7 ft. from the boiler fronts. This gives room for bins directly over the furnaces, which are supplied with slack coal by cars which run over the top of the bins and which are raised by a steam-hydraulic elevator. Induced draft is provided by a Sturtevant engine-driven fan, delivering the products of combustion to a 25-ft. steel stack set inside the building on a concrete foundation.

Engine Room

In the engine room all the auxiliaries, except the exciter and switchboard, are placed beneath the concrete floor. The electric-generating apparatus consists of a 1500-kw. Allis-Chalmers steam-turbine

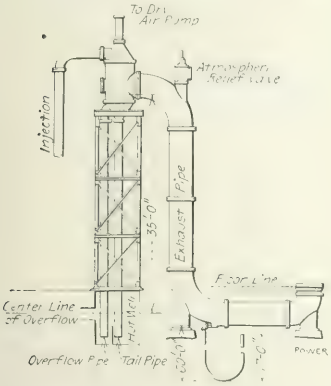


Fig. 3. Condenser with Automatic Drain Trap

set, which delivers three-phase, 60-cycle current at a terminal pressure of 2300 volts. The turbine receives steam at about 150 lb. pressure and exhausts at about 28 in. vacuum to an Allis-Chalmers condenser, of the barometric type, which consists of a 42-in. head provided with an air cooler, water distributor, spray plates and equalizing pipes. With this is operated a horizontal, double-acting, rotative dry-air pump, with cylinders in tandem, protected by a water and air separator on the condenser head; also a motor-driven centrifugal pump for circulating the condensing water, and a small drain pump for automatically removing the condensation from the exhaust piping. The latter pump, however, is used only in emergencies, as the exhaust line is drained by a 3-in. pipe which runs down the shaft a vertical distance of 60 ft. and then turns up vertically for a distance of 17 ft. This automatically seals the vacuum and allows any accumulated water to drop down the shaft, as shown in Fig. 3. A 10-in. motor-driven centrifugal pump lifts the water from the hotwell to the top of a cooling tower from which it is returned to the injection system after being cooled as falling spray. Approximately 3125 gal. are used per minute.

There is a completely equipped switchboard, and current is led from the busbars to three oil-insulated, water-cooled transformers having a capacity of 500 kilovolt-amperes each, which step up from 2300 volts to 30,000 volts for transmission. As the transmission line will be operated when necessary at 60,000 volts, the transformer secondary coils are so wound that they may be adapted to that voltage by changing the connections.

In addition to the generating unit, the station at the Maas mine contains two steam hoists and a two-stage air compressor furnishing 4800 cu.ft. of free air per minute. The Princeton station is similar to the Maas station.

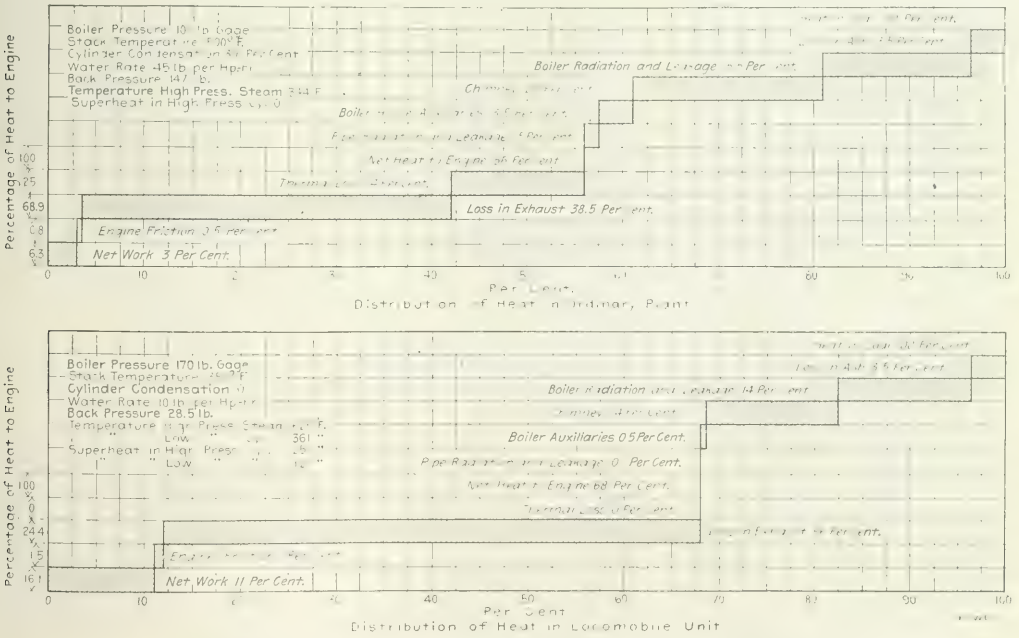
The work is being carried out under the supervision of O. D. McClure, resident engineer for the company, and Viele, Blackwell & Buck, of New York, as consulting engineers.

Locomobile vs. the Small Plant

By G. A. Glick

The accompanying chart is compiled from a number of recent articles in various technical papers concerning the locomobile unit. The type of locomobile unit referred to in the present case is a tandem-compound engine mounted on top of the boiler, the high-pressure cylinder being set in the stack and the low-pressure cylinder in the steam dome. High-pressure steam is used and superheat in both cylinders. Superheating the steam between the high and low cylinders is one of the features of the engine. All the boiler and engine auxiliaries are mechanically driven, and a high vacuum is used, the condenser usually being part of the unit. The engine is built in small sizes and some remarkable results are claimed, such as one indicated horsepower-hour on 10 pounds of steam, and one indicated horsepower-hour on 1.3 pounds of coal.

The advantages of the locomobile are that the stack temperature is low, the boiler and engine auxiliaries are mechanically driven, all piping is very short, thus reducing radiation, and the super-


Percentage of Heat to Engine
Boiler Pressure 10 lb. Gage
Stack Temperature 500° F.
Cylinder Condensation 8% Per Cent
Water Rate 45 lb. per H.P.H.
Back Pressure 14.7 lb.
Temperature High Press. Steam 344° F.
Superheat in High Press. 0
Boiler Radiation and Leakage 5 Per Cent.
Net Heat to Engine 36 Per Cent.
Loss in Exhaust 38.5 Per Cent.
Engine Friction 3.5 per cent.
Net Work 3 Per Cent.
Per Cent.
Distribution of Heat in Ordinary Plant
Boiler Pressure 170 lb. Gage
Stack Temperature 250° F.
Cylinder Condensation 0
Water Rate 10 lb. per H.P.H.
Back Pressure 28.5 lb.
Temperature High Press. Steam 361° F.
Superheat in High Press. 15°
Boiler Radiation and Leakage 14 Per Cent.
Boiler Auxiliaries 0.5 Per Cent.
Pipe Radiation and Leakage 0 Per Cent.
Net Heat to Engine 68 Per Cent.
Net Work 11 Per Cent.
Per Cent.
Distribution of Heat in Locomobile Unit

Heat Distribution in Locomobile Unit Compared with That of Ordinary Plant

heat overcomes the cylinder condensation. The very savings themselves help because they in turn cut down the size of the boiler and therefore the boiler radiation.

Compared to this unit as described is the ordinary small plant of 100 horsepower, which usually runs noncondensing. The example may be in the other extreme, but many such plants exist.

The chart shows the heat losses in both types, and some comparison may be made of the magnitude of these losses.

The locomobile has been in operation in Germany for some time and is a decided step toward advancement. Several features look dubious to steam practice in this country, such as 625 degrees Fahrenheit initial temperature, and the high vacuum of 28.5 inches of mercury, corresponding to 90 degrees Fahrenheit. The unit probably has some disadvantages in the way of a better class of labor being required for operation and a better grade of oil for the cylinders; but if the actual saving in coal is reasonably near the figures here calculated, the unit would without doubt be a great saver in the cost of operation.

Care of Belting in the Factory

By A. E. Derby

Suggestions as to keeping belts clean and removing oil, the proper lacing and the use of belt dressing with simple directions for testing it.

It is very important that a man operating belt-driven machinery know how to properly glue, lace and clean a belt; keeping it clean is a big factor in the life of a belt. There are many things that happen for which the operating man is blamed that are no faults of his, as there are many mistakes made in placing machinery that will always cause belt troubles. However, it is always well to know where to look for them and a little forethought when ordering the machinery set will often avoid many later troubles.

One plant of which the writer had charge, had a muleshaft running a right-angle turn, with a 12-in. heavy double belt 68 ft. in length. On account of its getting saturated with oil and the pulleys being too small, causing them to run at too high a speed on cast-iron bushings that stuck to the shaft because they heated so rapidly and requiring the oil to be kept running all the time, they caused all kinds of trouble and necessitated a shutdown of one entire department of the plant. This was rectified by taking off the 24-in. pulleys and using bronze bushings on two 48-in. wood pulleys, thus reducing the speed from 360 to 180 r.p.m. No more trouble was experienced, and the oil could not reach the belt after the change. As a rule, most muleshafts are fitted with small pulleys, which is bad practice.

Another poor arrangement was a lineshaft placed under a row of emery-wheel arbors employing 4-in. heavy double belts running at a speed of 2000 r.p.m. with a 12-in. driver and a 4-in. driven pulley, the lengths of the belts being 6 ft. They gave considerable trouble until equipped with small tighteners and glued joints. Before the change a row of 20 of these kept a man busy lacing them nearly all the time, but they gave very little trouble after the change.

If running an exhauster or blower or other high-speed machine and all of a sudden the belt slips to one side, it is necessary only to wrap a piece of cotton cloth about 1 in. wide for six or eight thicknesses around the crown of the pulley in the direction the belt runs. This should not be depended upon for lasting many days as it is only a means of saving the belt at the proper time.

When a laced belt runs over to one side of the pulley, it may be turned over to run on the other side, and if this does not make it run on the center of the pulley the lacings should be taken out and one end of the belt cut at an angle, about ⅜ in. to every 4 in. of width, at the side to which it slips; then relace as shown in Fig. 1. Belts should never

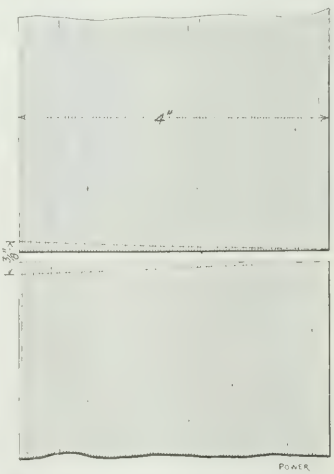


FIG. 1. SHOWING PIECE TO BE TAKEN OUT TO PREVENT RUNNING TO ONE SIDE

be allowed to run against sticks or rods to keep them in place; this destroys the edge by causing it to open up and become longer on that side.

One cannot be too particular about keeping the belts clean, as it is safe to say that 99 per cent. of the factories are run without a moment spent in cleaning belts, while every week some time is allotted to cleaning the machinery which they run.

To clean a leather belt take a stiff scrubbing brush with some benzine or gasoline and scrub vigorously on the running side. Then scrape with a metal or hard-wood scraper and wipe thoroughly dry. Apply a little neatsfoot or castor oil to tone up the leather. A better way is to have a round tank made with a cover and a drip near the bottom; it should be large enough to accommodate the belts used in the factory, and deep enough to cover them when raised a little off the bottom. Fill to the top of the belts with benzine or gasoline and allow them to soak; then squeeze them between rollers or a press to force out all the grease, and finish as before mentioned.

By taking care of the old belts they can be cut up and made into smaller ones. They can be ripped square on a rip saw, but it is not necessary to use the best saw for this purpose; one of small diameter may be used and it only needs to run a little above the table over the thickness of the belt.

When repairing belts do not fill them with iron rivets or hooks; use wood pegs, as they will cut up and not injure the tools used, and it is much easier to repair and make them over into smaller sizes.

The best way to fasten belts is to glue them, and no stretchers are needed when the length plus the lap is known. Take a short board a little wider than the belt and nail both ends on the board with the lap square; have the belt off of the pulleys and then glue; leave it there until dry; then pull out the nails and the belt is ready. The lap should be made 1½ times the width of the belt; if the leather is old the lap should be twice the width of the belt.

To have a rawhide lacing last, the holes should be in line with the joint of the belt and if the belt is heavy and running at high speed over small pulleys, a hinge joint should be employed. To lace a hinge joint, make two rows of holes ¾ in. apart, with one hole less in the back row; start the lace in the center holes with the middle of the lace and go to both edges and re-

turn. Every stitch should be turned through the belt joint; then finish in the center with a knot through a slit in the other end of the lace. (See Fig. 2.)

Wire lacing is good, but it has its drawbacks as it breaks at the edges of the joint first, causing the end to stick out and being dangerous to those who handle it. It also requires considerable time to repair, it being necessary to take the belt away to the machine that prepares it for the wire. It should not be used where the belts are handled with the hands while in motion. There are many metal belt fasteners that are useless for the same reasons, and they destroy the face of wooden pulleys and soon break the leather across the belt at the back of the fastener.

When using tighteners or guide pulleys always apply them to the slack side of the belt and near the driven pulley. An arrangement for adjustment should always be made at the heel of such pulley frames, as the least movement, in or

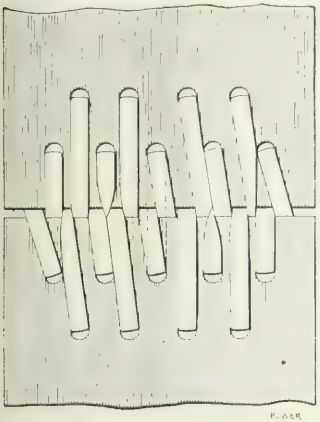


FIG. 2. METHOD OF LACING BELT

out, up or down, will make a great difference in the position of the belt on the driven pulley while running.

The strongest part of the leather is near the flesh or the rough side of a belt, but it is best to run with the grain or hair side on the face of the pulley, because this side is liable to crack when stretched after the belt has been in use some time; therefore, it is better to crimp than to stretch it.

Keep the belts free from the accumulation of grease and dirt, especially with lubricating oils, and do not let them run until they are hard and brittle on the running surface before applying a good belt preservative.

One should be careful as to the belt dressing used, as there are many on the market that are worthless. The points to be considered in belt dressings are lengthening the life of the belt, keeping a belt from slipping and the length of time it will last after being applied; does it pay to use it, and will it mix with the oil used about the machinery? First, to lengthen the life of a belt simply means keeping the belt clean, applying a preservative when the belt is seen to be getting hard; then use a dressing that is an oil and water repellent. Second, keeping a belt from slipping excessively is one of the hardest problems as a belt slips when the load is too great to be overcome by the adhesion of the belt in the condition that it is in and at the speed at which it is traveling. It is better to change the condition of the belt than to fill it with belt dressing. When the load is so great that the belt stands still and the driving pulley continues to revolve, it then burns the leather, and no amount of belt dressing will overcome such conditions. One must look elsewhere in order to have the belt perform its duty. A belt too tight means bearing troubles; therefore, the belt man must be able to tell his employer where the trouble is; this means good belt running in place of belt destruction. Third, as to how long a belt dressing will last after being applied may be judged from the following: Does it gather on the pulleys and belt in chunks and then fly about the room? This is the case in dusty and dirty places. Does it mix with the machine oil and become useless by filling the belts with a compound of machine oil and belt dressing? Under these conditions does it pay to use it? Fourth, if it mixes with the oil used about the machinery it only increases the oily condition, which is the cause of most belts slipping when they are in line, not too loose and of the proper size to do the work required.

Having experimented with belt dressings the writer found the following simple tests to overcome a large amount of trouble and expense: Take a piece of clean tin, pour onto it a quantity of the dressing equal to the size of a quarter, place over a small fire and heat until it smokes. If there is any rosin present, it will show many small, bright spots on the tin as rosin will clean tin. Now take a small bottle, add about half and half of belt dressing and machine oil and see if the two readily mix. If they do not, shake well or heat together, and if they mix when heated allow them to cool and see if they separate. If the dressing is too thick to mix when cool, make it thin by heating and then mix, and if they do not separate while cooling it is safe to assume that the dressing will be useless on oily belts. Never allow any rosin to be used on leather belts, as it soon rots the leather at the lace holes and joints where the fiber of the leather is exposed and the rosin accumulates.

Commercial belt dressings are used for making belts stick to the pulleys and to preserve the belt. The substances used in manufacturing these preparations include stearic acid, degras, rosin, castor oil and fish oil. Careful tests seem to indicate that the coefficient of friction is influenced directly by the absence of air or other substances between the belt and pulley, and that the best results are obtained when the belt is in direct contact with the pulley.

In conclusion, it may be said that a good dressing should not decompose, become rancid with age, be influenced by moisture, dry up, nor cause the belt to stick to the pulley when idle, as though glued there and when starting pull off the surface pieces that expose the fiber; instead it should soften the pulley side of the belt, penetrate the fiber, leaving no film on the surface, and in addition lubricate and protect the fiber from crumbling. It should prevent the generation of electricity by friction, and it should contain no mineral acids. A dressing fulfilling these specifications will not injure the belt and may be used with impunity.

The Purpose of Oil*

BY GEORGE J. STOLL

The primary purposes of oil are twofold: (1) Cooling. (2) The forming of a film, the molecules of which move among themselves like an infinite number of ball bearings to prevent the rubbing of the bearing surfaces. All mechanical motion produces heat. Heat in machinery produces uneven expansion with a resultant increase in friction. To keep the bearings cool is one of the important functions of oils.

For lubrication just the oil needed must be applied to the bearing. For instance, in the heavy, loose bearings there is great need for oil of high viscosity or body, because the thinner oil has a tendency to be pushed aside and will not cling tightly enough to the surface. To illustrate this point, consider a small circle within a larger one and touching it while spinning on its own center. The smaller circle represents the shaft, the larger the socket in which it runs. From this it may be seen that the tighter the bearing, the greater the surface on the shaft which touches the socket in its rotation. Thus on a loose bearing, where the circles are not so near the same size, there is more of a tendency to rub off the oil. On the tight bearing the opposite condition is presented. An oil must be used that will be thin enough to get in between the close-fitting parts and still give satisfactory lubrication. For instance, dynamos or turbines have tight bearings, and must have an oil of comparatively low viscosity.

The question arises, What effect has fire test? For the same viscosity, fire

*Abstract of lecture delivered before Kentucky No. 1, N. A. S. E.

tests vary with the different crudes. Why is it that Pennsylvania oil, having light gravity and viscosity, is often better than a Western lubricant of much higher viscosity and much heavier gravity? Conceive a bearing in motion—a small speck of dust or foreign matter, such as a little particle of waste, gets between the surfaces; it may be almost microscopic, yet it immediately produces great heat. A cheap oil of low fire test will tend to vaporize. The higher the fire test the slower the oil will vaporize, and a dynamo must have an oil that will not vaporize, but will remain there and cool the heated bearing immediately—an oil that will go to the spot. Were it not for just such troubles as this there would be little difficulty about proper lubrication. The above principles may seem elementary, but their proper application may save many difficulties. Recently a salesman called upon a large manufacturing concern, whose buyer said, "I take a pretty good oil; give me a good oil of good body; I have been paying 18 cents per gallon." The salesman accordingly ordered a heavy, viscous engine oil to produce the body desired. He did not know anything about the conditions inside the plant. He merely took the man's statement that he wanted body to the oil. That plant had very rapid-moving machinery with tight, close bearings; therefore the oil was too heavy to get to the spot quickly and the result was disastrous. He should have had light-bodied oil of an entirely different character. Both were the same price. On one the emphasis was placed on "viscosity," on the other, "fire test."

Lubrication within the cylinder requires an oil that will atomize with the steam and get to the cylinder wall to produce lubrication around the piston head. For the purpose of assisting both in the atomizing and the lubrication—that is, to help the oil emulsify—animal oils as low in acid as possible are often used. Cylinder stock of about 600 degrees fire test, as free as possible from any taint of tar and compounded properly with animal oils, is usually the best for ordinary wet steam, because it spreads better in this medium than does the mineral cylinder oil or the higher fire-test goods. Of course, in many instances where the exhaust steam is used over, it is impossible to use a compounded oil. For the high pressures which have high heat it is usually desirable to use an oil of about 650 fire test unfiltered, free from tar, and any compounding must be done with great care, because poor compounds of animal oils are subject under high heat to be broken up into acids, as stearic acid, which will attack the walls of a cylinder and pit them seriously.

It will now be apparent that the engineer has but a few elements to work with, but he can compound them in an almost endless variety, though this must be done carefully. Not only must first-class stocks be used, but they must be carefully and intelligently applied.

The Large Delray Boilers

Discussion following the presentation of Dr. Jacobus' paper upon the tests of the boilers at the Delray station of the Detroit Edison Co. This paper appeared in abstract in the Dec. 5 issue.

The discussion, of which this is an abstract, followed the presentation at the recent meeting of the Mechanical Engineers of a paper by Dr. D. S. Jacobus detailing tests conducted upon two boilers of over 2300 hp. rated capacity each, at the Delray station of the Detroit Edison Co. The paper was abstracted in our issue of Dec. 5 and is available in its entirety in the *Proceedings* and *Journal* of the society. The tests showed efficiencies of over 80 per cent., and a single boiler furnishes steam for an 8000-kw. unit.

R. D. Rice, of the General Electric Co., commented upon the absurdity of rating boilers by horsepower, and pointed out that the tests gave no indication of the comparative merits of the two stokers except so far as their efficiencies are concerned. The other items, such as ease of handling, smokeless combustion and cost of maintenance, which, to the mind of an engineer, are essential, do not come within the scope of the paper.

The blowing off of 75,000 or 100,000 lb. of steam into the atmosphere in the case of a sudden stoppage of the turbine is a serious matter, and in such installations means will have to be taken to protect the boiler by the immediate injection of a large amount of feed water in order to reduce the temperature. Tests with a flow meter have shown that a boiler can have its output reduced almost to zero in a short time by the introduction of cold feed water, and these experiments indicate in the case of such large units the necessity of an arrangement for an accurately graduated feed following closely the demand for steam on the boiler, so that the disturbance by the feed of the steam capacity of the boiler can be reduced to a minimum while maintaining a constant pressure.

In these large units fluctuations in feed supply are likely to lead to large fluctuations in pressure when operated as single units. Furthermore, the stresses on the boiler due to expansion forces will be greatly reduced by the use of such graduated feed.

R. E. DeWolf submitted some curves, the first of which, Fig. 1, shows that for the two boilers, built by the same company, from identically the same specifications, a considerable difference exists in the drop of pressure through the superheater under the same working conditions.

In Fig. 2 are shown the input and output in units of 1,000,000 B.t.u. for the boiler equipped with the Roney stoker; the points marked 2-4 and 5-6 include the period between tests and are, therefore, at a somewhat lower efficiency.

The same curve for the boiler equipped with the Taylor stoker is shown in Fig. 3. Here again the point including the period between tests and the point 15, which includes 7½ hours of banking, are below the curve. Fig. 4 shows the variation in temperature of the flue gas with the rate at which the boiler is run; and Fig. 5 the relation between the percentage of CO_2 and the rate at which the boiler is operating.

In Fig. 6 is given the percentage of steam which is used by the boiler auxiliaries; that is, the stoker engine and the turbine operating the fan for the Taylor stoker. The lower full line curve shows the steam used by the steam jets in the Roney stoker. The dotted curve is purely theoretical, being taken at 25 per cent. of the Taylor curve, and is intended to indicate in a general way the loss of heat energy from the steam used by the stoker engine and the turbine for the Taylor stoker equipment.

H. O. Pond, of Westinghouse, Church, Kerr & Co., who presented the paper in the absence of the author, showed a number of lantern slides from photographs taken during erection, from which we have selected those shown in Figs. 7 to 10, inclusive, as giving an idea of the magnitude of the work.

He said that in a plant with less excellent feed water the advisability of using such large units would be somewhat questionable. The most striking point to him in the test was the small difference in efficiency (only about 6 per cent.) shown in a range of over 100 per cent. in capacity. With boilers showing such sustained efficiences it would seem advisable to run all the boilers all the time instead of banking many of them as in present practice.

Prof. W. D. Ennis said that in a curious old autographic letter by James Watt, which he had recently seen, Watt refers to a "colossal" new boiler which he was then building which exposed 300 sq.ft.

of surface to the fire, whereas his largest previous boiler contained only 170 sq.ft. The Delray boiler is not only big, it is efficient. A 75 per cent. running efficiency, including a lay-over period of seven hours, with a load varying from rating to double rating, means a great deal in power-station practice. With a turbine giving a brake horsepower on 220 B.t.u. per minute and with a brake-

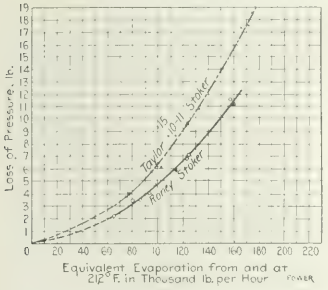

Loss of Pressure, In.
Equivalent Evaporation from and at 212° F. in Thousand lb. per Hour
Taylor - Wolf Stoker
Roney Stoker
POWER

FIG. 1. LOSS OF PRESSURE THROUGH SUPERHEATER AND EQUIVALENT EVAPORATION

to-switchboard ratio of 1 to ½, it means 26,400 B.t.u. in fuel per kilowatt-hour, or about 1.9 lb. of coal. This economy was obtained, not at a 3- or 3.5-lb. evaporation rate, but at one running as high as 7 lb.

For a city power station the cost of land and buildings and interest thereon will be approximately in the inverse ratio of these evaporation rates. The big boiler is efficient commercially as well as thermally.

In some respects, the operation was not remarkably economical; the loss to

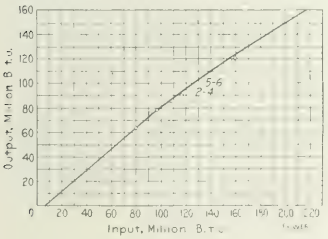


FIG. 2. INPUT AND OUTPUT WITH RONEY STOKER

the ashpit was not especially low, and it would have been a conspicuous item had the coal carried a greater percentage of ash. The flue-gas temperatures were not particularly low. The ratios of heating to grate surface (as the latter were measured) are 53 and 58½, certainly not extreme figures. The unaccounted-for (presumably radiation) loss was low, as should be expected with the low ratio of setting surface to the heat generated, which must prevail in a large boiler. This has a particularly important influence on the rate of heat transmission, because a comparatively slight radiation loss means a considerable reduction in the transmission factor, due to temperature gradient through the heating surfaces.

The explanation for the high furnace efficiency lies in the form and dimensions of the furnace, which is exactly adapted to produce a thorough mixture and impingement of the gases. With the very low draft normally carried, stratification

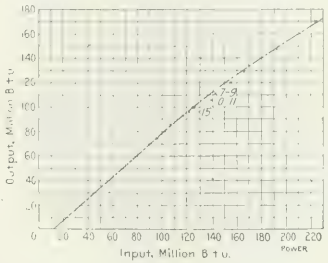


FIG. 3. INPUT AND OUPUT WITH TAYLOR STOKER

must have been almost impossible. This is demonstrated by the composition of the gas, which shows a maximum of 0.5 per cent. of CO, with the CO_2 ranging from 10.35 to 16.50 per cent. The loss of fuel heat due to the formation of CO was only 0.16 to 0.38 per cent.

In the great majority of plants where a large excess of air seems to be the normal and almost inevitable condition of operation, the best percentage of CO_2 is the highest attainable. This does not hold for such advanced practice as Prof. Jacobus' paper represents. The situa-

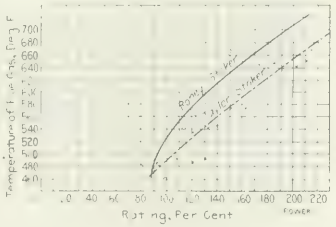


FIG. 4. PER CENTS OF RATINGS WITH DIFFERENT FLUE-GAS TEMPERATURES

tion then is somewhat as suggested by the curves in Fig. 11. As the air supply decreases, the loss due to excess air (CO_2 loss) also decreases, but at some certain point, which may be different for every furnace and every condition of operation, the formation of CO begins to be an important offsetting factor. The air supply for the best efficiency is that determined by the minimum point of the combined curve. This point has been quite closely approximated in the tests reported in the paper.

H. De B. Parsons attributed the excellent results obtained to the fact that the fire is so far from the heating surfaces and the combustion chamber is so large that a thorough mixture of oxygen and fuel can be maintained and combustion completed before the products are made to pass over the water surfaces, the distance from the grate to the tubes being about three times that in ordinary boilers.

The gas analyses show that the surplus air was only about 27 per cent. of

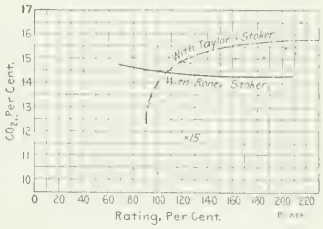


FIG. 5. PERCENTAGE OF CO_2 WITH VARIOUS RATINGS

the theoretical amount, the quantity of air supplied per pound of coal being between 14 and 14.5 lb. Under the conditions described in the paper, the theoretical maximum efficiency attainable would have been about 87 per cent.; therefore, the efficiency ratio—that is, the ratio between the actual efficiency and the theoretical efficiency—was about 89 per cent., which is truly a remarkable showing.

Horace H. Esselstyn, of Westinghouse, Church, Kerr & Co., said that they had

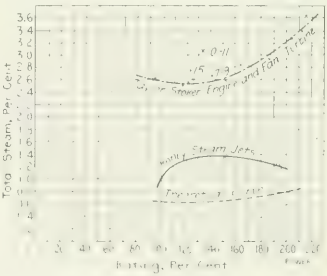
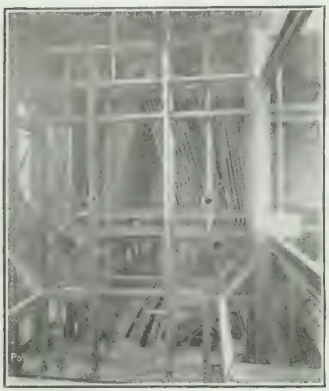


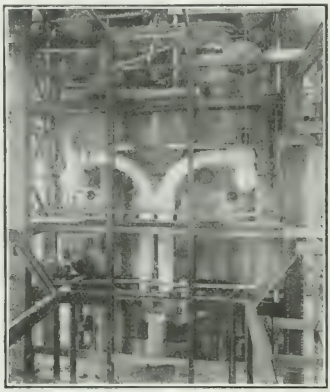
FIG. 6. TOTAL STEAM WITH DIFFERENT PER CENTS OF RATING

expected to have trouble with the brickwork of these large furnaces, and as Mr. Pond had shown the arch ultimately adopted he would show some of those tried out before it was determined upon. Fig. 12 shows the various arches tried with the Roney stokers, No. 4 being that used at the time of the test and No. 7 that still working satisfactorily. Fig. 13 shows how one of the arches came down.

E. G. Bailey, of Boston, called attention to the lack of agreement in the tests of the fuel. Out of 26 tests of

such analyses, there were only two cases where the ash reported by the Solvay laboratory was lower than that reported by the Babcock & Wilcox Co. From the average results of the two laboratories, the Solvay laboratory reported 1.39 per cent. higher ash and 300 less B.t.u. than the Babcock & Wilcox Co. On individual Jacket coal and 6.30 from the Milburn coal. While there is always some ash carried away by the escaping gases, it would probably be a small factor for this particular setting. If the average of 6.90 ash, as determined by the Solvay laboratory, were correct, the ash carried away by the gases would be 20 per cent. of combustion was below 20 lb. per square foot of grate per hour, is 5.38 per cent., while on the three tests having a rate of combustion of about 30 lb. it was 6.62 per cent. The general conclusion to be drawn from this is that the true average ash in the coal used was about ½ per cent. lower than the aver-





FIGS. 7 TO 9. SHOWING VIEWS OF THE BOILER UNDER CONSTRUCTION

samples the difference between the results of the two laboratories ran as high as 3.40 per cent. ash and 929 B.t.u., or over 6 per cent. of the heating value.

While no coal, even from the same mine, runs absolutely uniform, such variations as these are so exceptional that they cast doubt upon the accuracy of the sampling and analysis. Even the heat content, which is practically a constant for coal from a given mining district, varies 750 B.t.u., or 5 per cent. per pound of combustible, as determined by one of the laboratories, while the other reported results in which this factor varied 600 B.t.u., or 4 per cent. The variation in this factor as determined by the two laboratories from the same original sample showed variations of similar magnitude.

The erratic variations in the ash indicate that sufficient care was not used in taking and working down the samples. Properly taken, duplicate samples should have checked in each individual instance within 0.50 per cent. of ash, and the average should have been within 0.10 per cent. There are also other differences in the volatiles, heating value and ultimate analyses that indicate greater variations in the laboratory work.

A check is available on the ash by taking the weight of dry ash, as weighed from the boiler test, and correcting it for the percentage of combustible. The two laboratories agreed reasonably closely on the moisture and combustible determinations from the ash.

The average net dry ash as determined by this method is 5.53 per cent. from Red of the total ash, while the Babcock & Wilcox average of 5.71 per cent. corresponds to a loss of 3 per cent. from the grate. If any appreciable amount of ash were carried away by the draft it would be more pronounced on the test age of the two sets of laboratory determinations.

The heating value per pound of combustible corrected for sulphur, as determined in two laboratories, was about 3 per cent. below the corresponding re-

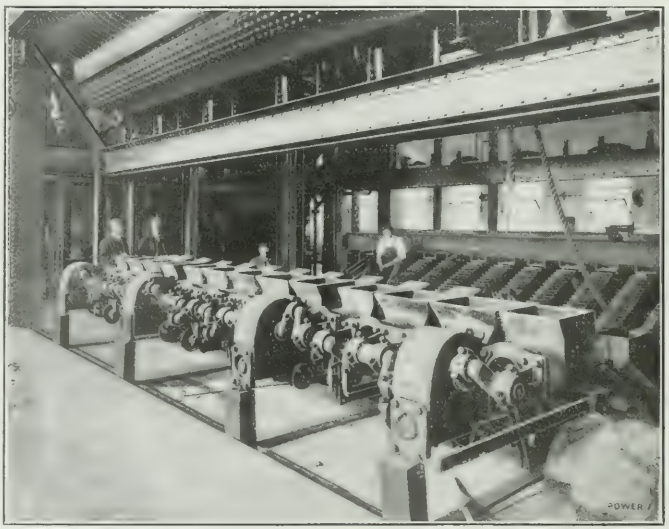


FIG. 10. TAYLOR STOKERS IN PLACE WITH BOILER FRONT REMOVED

with the higher rate of combustion, but the plotting of these results fails to indicate any such relation. On the other hand, the weighed net ash on the six tests of Red Jacket coal, where the rate sults obtained by the United States Geological Survey and the West Virginia Geological Survey. The latter results agreed closely with the work of other laboratories that have had their calorim-

eters and thermometers calibrated by the United States Bureau of Standards.

The disagreement in the ultimate analysis as made in the different laboratories indicates that very little confidence is to be placed in the heating values calculated from this analysis. The true heat value should be known.

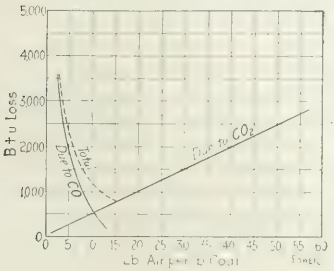


FIG. 11. RELATION BETWEEN AIR SUPPLY AND THERMAL LOSS

W. F. M. Goss, dean of the University of Illinois, said that the relation between the evaporative efficiency and the rate of power developed was one which he had studied with care in its application to locomotive boilers. The decrease in efficiency accompanying an increased rate of driving is not only relatively less than that observed in boilers with which he is familiar, but is actually very small. This fact suggests the practicability of developing the type of boiler under consideration, for work at even higher rates than has yet been attempted. It appears probable that by increasing the grate area or by altering the rate of combustion, this type of boiler may be made to evaporate 10 or 12 lb. of water per square foot of heating surface per hour, with an efficiency which will be well above 70 per cent.

E. P. Dreyfus, of the Westinghouse Machine Co., recalled that the 10,000-kw. turbine unit, described in the last issue of the society's *Transactions*, required 17,250 B.t.u. per kilowatt-hour at three-quarters load with a boiler efficiency of 75 per cent., the combined results, including boiler losses, being 22,000 B.t.u. In large plants using steam-driven auxiliaries with their exhaust returned to the boiler, the increased consumption which they occasion is well within 5 per cent. He believed it safe to say that such a plant would run on 24,000 B.t.u., or 2 lb. of coal per kilowatt-hour.

Prof. R. C. Carpenter, of Cornell University, said that the high results were entirely due to the method by which the furnace was handled, to the very high grade of coal used and to the remarkable control of the air supply. The results of the flue-gas analyses in all these tests show that they were run at just about the limit of CO_2.

FIG. 13. FALLEN ARCH

John C. Parker, of the Parker Boiler Co., compared the present tests with those made by H. F. Stott at the Fifty-ninth St. station of the Interborough Rapid Transit Co., and reported to the American Institute of Electrical Engineers four years ago. Taking the highest test with the Taylor stoker and with nearly forty pounds of coal per square foot of grate, Mr. Stott would have had to increase his combustion efficiency 42 per cent. to equal the results obtained at Detroit.

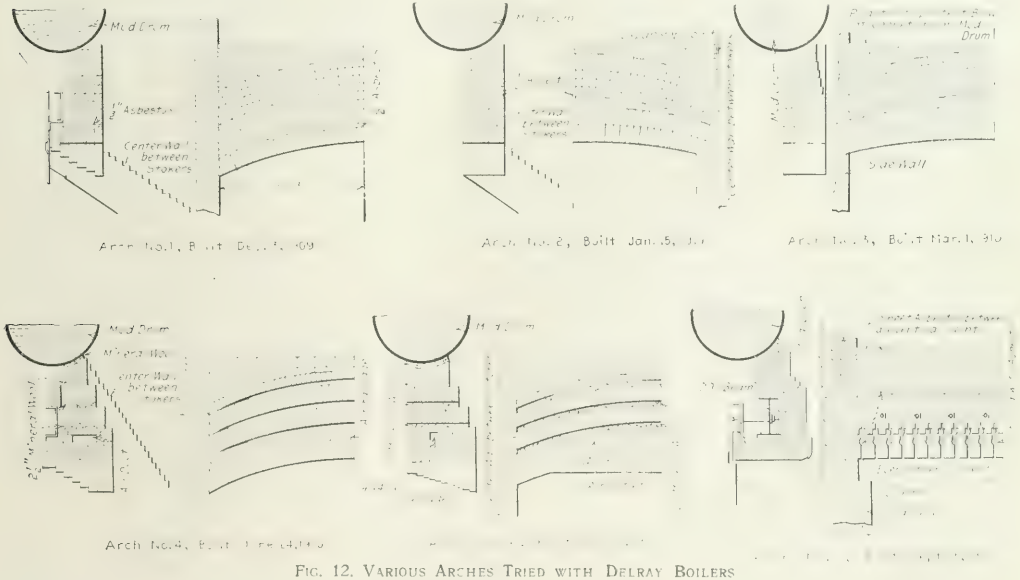

Mud Drum
1" Asbestos
Center Wall between Stokers
Side Wall
Arch No. 1, Built Dec. 2, 09
Arch No. 2, Built Jan. 5, 10
Arch No. 3, Built Mar. 1, 10
Arch No. 4, Built Dec. 14, 10

FIG. 12. VARIOUS ARCHES TRIED WITH DELRAY BOILERS

Fuel Economies in Factories*

By Dr. Charles E. Lucke†

The author compares the advantages offered by steam and producer gas for the four uses for which heat is employed in industrial establishments: Power, heating, lighting and industrial processes; and finds a substantial balance in favor of the gas system when mantle light for weak gas and gas fired evaporators, concentrators, cookers, etc., shall be available.

*Abstract of paper presented to the New York section of the American Chemical Society.

†Professor of mechanical engineering at Columbia University.

In conducting the financial operations of a business, no one would think for a moment of dispensing with records of expenditures and income or would fail to provide a more or less elaborate cost system for distributing the expense over the various parts of the apparatus used in production and for dividing the cost of the products into the different elements that make it up. Cost information is worth as much as the possible saving in cost of production to which the information leads.

Necessity for Heat Accounting

There can be no rational attempt made toward fuel economy in a given system of manufacture using fuel, without a knowledge of the distribution of the heat of that fuel, though it is quite possible that the information may not be of sufficient value to warrant as complete a distribution of the expense of heat supply or as elaborate a system of records as would be warranted in the case of labor or materials entering directly into the factory product. However, there can be no question as to the absolute necessity for some heat accounting to determine the coal-heat charge to be attached to each individual process using heat and to show sources and quantities of utilizable waste heat, however simple the system of the accounting may be, nor can there be any doubt as to the increasing justification for more and more elaborate records as coal cost forms an increasing fraction of the total cost of production.

Four Classes of Service

It may be assumed that in a factory fuel enters directly or indirectly into four classes of services, all of which are essential to the making of the product, namely, power; factory heating in cold weather; factory lighting, and direct manufacturing processes, as heating, cooling, evaporating, condensing, melting and drying.

The primary process in the use of heat is the making of steam on the one hand or the gasifying of coal on the other, and the direct loss encountered in either of these processes is the first factor for measurement and record in the heat-accounting system. This first step of conversion may be had with an average efficiency of 65 to 75 per cent. for the steam system, depending on the coal, proper firing and the type of equipment; and an efficiency of from 75 to 85 per cent. for the gas system, showing a clear gain of about 10 per cent. for the gas system on the average for this first step, with, however, a limitation. This limitation is the inability of the producer to handle as wide a range of fuel with equal success to that attainable in the boiler.

Steam once made is transmitted in pipes for short distances only, and under high pressure, with a constant heat loss for every foot and involving high maintenance charges, on its way to engines for shaft power or electrical generation. Gas, however, may be transmitted at low pressure over long distances to all the buildings of large establishments or to neighboring establishments or from a central gas-generating station dozens of miles distant through pipes, and transmitted cheaper than those required for steam and with almost no maintenance cost in comparison. This pipe-distribution cost is the next item in the accounting and, without setting down numerical values, is again plainly in favor of the gas system; it involves no heat loss whatsoever while the steam involves a large one and the pipe-maintenance costs are hardly comparable.

The next step is the conversion into work in the engine of the heat carried by either the gas or the steam. Here the balance is again in favor of gas as the gas engine is a more efficient heat converter than the steam engine in the small sizes found in the average factory —and even in larger sizes also, though to a lesser degree. Few factories would find occasion to use engine units exceeding 1000 horsepower, which size, operated condensing, whether of the turbine or compound Corliss type, will yield thermal efficiencies less than 20 per cent., whereas if operated noncondensing these efficiencies would drop to at least 15 per cent.

A smaller steam-engine size of, say, 100 horsepower, will be less efficient and the turbine would not be so good as the piston type, though the difference would not be so great. For this size the dependable efficiency would be about 15 per cent. when operated condensing and not over 10 per cent. when operated noncondensing. A comparison of these efficiencies with the substantially constant thermal efficiency for the gas engine in all sizes, of 25 per cent., will indicate a margin in favor of the gas of at least 5 per cent. over large steam engines condensing, 10 per cent. over the smaller condensing and the large noncondensing, and 15 per cent. over the small noncondensing steam engines.

If electricity is generated and transmitted for lighting or for use in electric motors, the efficiency of electrical generation, transmission and reconversion to power and light is the same for both systems.

Economy of Individual Gas Engines

Another item not generally or sufficiently appreciated may be put on the credit side of the account in favor of gas and that is to set down small individual gas engines at the spot where power is required and transmit gas with practically no loss instead of generating electricity and transmitting it to electric motors with three losses. This would not only save the expense of the electrical equipment but would save all electrical losses, which are often considerable when the generator and the motor work at unfavorable loads. This is feasible and will give substantially the same efficiency of conversion as is obtainable in a single large central engine, a fact which especially distinguishes the gas from the steam system.

Concentration of small steam engines into a single large one always results in steam economy, a fact which has led to constant concentration of steam systems into larger and larger central generating units, so that steam may be regarded as a centralizing influence. The constancy of gas-engine efficiencies, on the contrary, in large or small sizes, must characterize the gas system as a decentralizing influence in the interests of economy.

Factory Lighting

Take next the question of factory lighting, which may be electrical, with current supplied by either steam- or gas-driven generators, and which can be only electrical for steam-engine driven generators but may be something else when gas is available. There is no good reason for assuming that mantle lights of fair brilliance and moderate gas con-

sumption cannot be produced to operate on weak producer gas for factory lighting and as soon as they become available—as they surely will when the demand becomes pressing enough—mantle gas lighting with producer gas will displace to a very large extent electric lighting in those establishments where the gas system is used for power and heat and gas transmission is substituted, at least in part, for electric.

Factory Heating

Heating of buildings is almost universally accomplished by means of steam- or water-heated radiating surfaces at a temperature of about 200 degrees Fahrenheit, and there is no good reason for changing the system. The preparation of this low-pressure steam or moderately high water can be done with equal efficiency by either the gas or the steam system in cold weather, though the latter again receives a credit charge for all the rest of the year when heat is not required.

For example, if the exhaust steam from steam engines is used it must be at approximately atmospheric pressure to give a sufficiently high temperature, or live steam must be used either alone or added through reducing valves as make-up. In any case, the heat put into the heating system gives about 100 per cent. effect in the warming of buildings, especially when drips are returned. This is also the case for the gas system as jacket-water heat and exhaust-gas heat can be combined for the same purpose and fresh gas drawn upon through thermostatic gas burners to supply any deficiency.

By either method the effect is a full use of heat and 100 per cent. efficiency in the use of fresh supplies of heat in the warming of the building. During the time there is no building heat, which in New York City lasts for more than half the year, the waste heat of the steam engine is far in excess of that of the gas engines, especially if the former be noncondensing, as is usually the case where exhaust-steam heating systems are employed, so that, measured over the whole year, the gas system is again most favored.

Heat for Manufacturing Processes

There remains now to examine the possibilities of credit or debit items for the two systems in applying the heat to the direct manufacturing processes, which for convenience may be divided into low-temperature heating and high-temperature heating; the former includes most of the evaporating and drying processes and the latter the roasting, baking, melting, etc. All low-temperature processes can be carried on by steam-jacketed chambers or by steam-coil apparatus using live or exhaust steam, a fact which has led to the design and mechanical perfection of many appliances now regarded as standard and for which there is no gas-heated equivalent.

There is no good reason why equivalent apparatus should not be quite as effectively designed, and with efficiencies over 90 per cent. for operation with gas burners, but, like the mantle light, the need is not strong enough to warrant their production. Such evaporators, concentrators, cookers and driers as fall in this class will, when gas heated, offer still further simplification of piping and reduction of piping loss over their steam-heated equivalents and should be equally effective.

High-temperature heating can be accomplished only by oil, piped illuminating gas or by independent coal fire with the steam factory system, while the gas system offers a possibility of the producer gas-fired furnace for practically all services, and with almost perfect temperature control, better by far than is possible with oil or coal, and it is more economical because both excess air and incomplete combustion can be eliminated.

Thus, for the heating processes of manufacture the gas system offers the same high-temperature source of heat, a gas fire, for all, while the steam system requires fresh fuel for the high temperatures, accomplishing the low-temperature service with live or exhaust steam; the former is not an accomplished fact simply because no one is yet prepared to sell gas-fired appliances to take the place of steam-heated ones.

Gas and Steam Systems Compared

Comparing gas and steam systems broadly by summarizing the preceding brief analysis, it appears that the self-contained factory plant may be much more economically operated by the former than by the latter for all the services of power, lighting, building and process heating. This is not all, for there is also in favor of the gas a simplicity in the heat-balance determination for the gas over the steam so great as to make it easier to keep the operating economy nearer to the high possibility by quick and easy determination of wastes.

For example, by means of a central gas meter and as many individual distributing meters as the separate consumptions of gas, the gas generated may be easily known, as well as its distribution throughout the plant, by so simple a procedure as the reading of meter dials. Add to this recording calorimeters, and gas-meter readings can be reduced by one multiplication to heat consumed by each part of the system. With such a ready check on consumptions and losses, it is sure that heat accounting will be practised because the cost of the account will be small; therefore, the plant may be operated at somewhere near its good economy point.

This is in most striking contrast to the case of the steam system, where the possible economy is not only less but where the realized economy is so much below its own maximum possibility simply because of the difficulty of making the measurements necessary to a heat balance with reasonable accounting costs. In the first place, it is impossible to continuously measure the heat supplied in steam because there is no reliable and cheap steam meter available; even if there were, the heat equivalent of a pound of steam constantly varies with feed-temperature steam, pressure and its wetness or superheat.

Pipe-line losses can be determined only by collecting and weighing drips; steam consumption of the various appliances and its heat equivalent are a matter of recording meters, steam calorimeters, thermometers, pressure gages and automatic water weighers. To keep up all the instruments of this sort that would be needed would in most cases cost more than the information would be worth.

Why is it, in view of both the higher possible economies of the self-contained gas-factory system for the four classes of factory service and the correspondingly easier and cheaper fuel accounting that would follow its use, that there is to be found no such system in use? The answer is as complex as a detailed study of the systems, but a few facts stand out prominently. First, the inertia of the human mind, which resists the mental effort necessary to bring about a change when things seem to be running fairly well in the older way. There is always a latent suspicion that the new thing may not work, however clear it is, put on paper, and even if the manager is convinced, his board of directors are ordinarily incapable of thinking of anything but the factory's past performance, however willing they may be to deal in the fixtures of stocks and bonds.

So far in this particular case there has been some good reason for suspicion, not of the scientific and engineering possibilities, but of the business expediency of a general change because of the lack of standardization or mechanical perfection of some of the needed appliances. There are no producer-gas mantles for lighting, no gas-fired evaporators, concentrators or driers, and, most important of all, there is no universal gas producer capable of economically using any available solid fuel.

The gas-appliance makers should get to work on the problem of adapting apparatus for all the manifold services of lighting and heating to the use of weak producer gas and chemists and engineers should try to solve the gas-producer problem.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Repairing Induction Motor Winding

By R. H. Fenkhausen

Rewinding Stators

The simplest form of stator coil and the one in most common use by builders of motors for industrial service is known as the diamond-shaped coil. The pres-

Fig. 1. A Diamond Coil

ent article describes the operations required in the winding of a set of these coils. Before taking up the various processes in detail, I think it advisable to describe briefly a few of the more important factors governing the shape of this type of coil, for the benefit of the repair man who may be called upon to design a form for the coils without the assistance afforded by a sample coil. Of course, it seldom occurs that a winding is so completely destroyed that the original coil shape cannot be determined, but occasionally the winding is removed by a helper who neglects his instructions to preserve the shape of one coil, leaving the repair man no information other than the size of wire and number of turns.

Fig. 1 shows a diamond-shaped coil with the different parts named and Fig. 2 two coils in place on the stator of a motor, illustrating how each coil occupies the lower half of one slot and the upper half of another several slots away. The magnetizing power of a coil is directly proportional to the current it "carries" and the number of turns it contains, and is independent of the length of turn. It therefore follows that the shorter the turns the less copper will be required, and consequently the lower the resistance and less the loss in the winding. An inspection of Fig. 1 shows that the coil is a great deal longer than is necessary to inclose the iron, but this excess length is required in order that all the coils of the set may clear one another. The part of the coil lying outside the slot is practically idle wire, and is known as the "end connections." This term must not be confused with the "cross-connections" between dif-

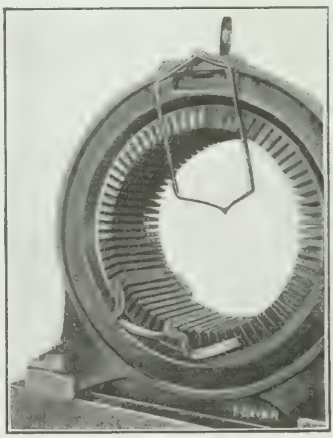


Fig. 2. Two Coils in Position

ferent groups of coils and the different coils of one group.

Coil Pitch

The length of the end connection is largely governed by the number of teeth spanned by the coil. This is called the "pitch" of the coil. The "full" pitch is equal to the number of teeth in the stator divided by the number of poles. In practice, however, the coil pitch is usually less than the "full" pitch; such a pitch is called a "fractional" pitch. For example: The stator shown in Fig. 2 has 72 slots and teeth and is wound for six poles. The full pitch, therefore, is $\frac{72}{6}$ = 12, and a full-pitch coil would span 12 teeth, lying in slots 1 and 13. The coils shown only span eight teeth and lie in slots Nos. 1 and 9, which is only two-thirds of the full pitch.

The fractional pitch has the disadvantage that the magnetizing current required with a given number of turns is greater than it would be with full pitch. This increase, however, is not proportional to the decrease in pitch; a two-thirds pitch, as shown in Fig. 2, only results in a comparatively small increase in magnetizing current.

The disadvantage just mentioned is over-balanced many times by the numerous advantages obtained by the use of a fractional pitch. The more important advantages are as follows:

(1) Ease of repair owing to the smaller number of coils which must be raised to permit a defective coil to be removed for repairs. This advantage is especially marked in high-speed or low-frequency motors having few poles and consequently large coil pitches.

(2) Better ventilation, owing to the air space left between the end connections. If the distance *E*, Fig. 3, be kept

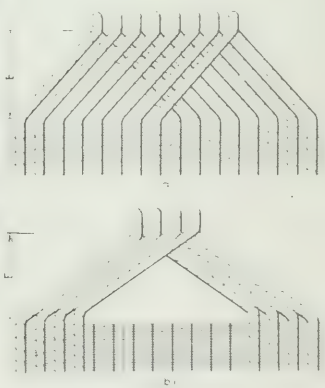


Fig. 3. Effect of Coil Pitch on Angularity of Ends

the same, the angle formed by the end connections will be more acute with the fractional pitch, as at *a*, than with the full pitch, as at *b*, and therefore the coils will be separated by an air space as shown.

(3) Less insulation is required on the end connections, owing to the pressure of the air space previously mentioned,

(4) Less copper is required, owing to the decreased length of end connections.

(5) Improved efficiency of the motor due to the decrease in copper and hence in the resistance loss in the winding. This will usually counter-balance the increased magnetizing current required.

(6) In practice the distance E (Fig. 3) to which the coils project beyond the core will be decreased, because the gain in space between coils will be greater than is necessary for adequate ventilation and insulation. By making E less, the end connections and copper loss are further decreased.

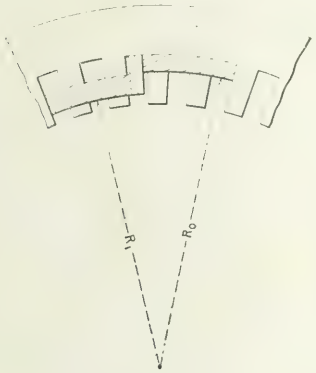


FIG. 4

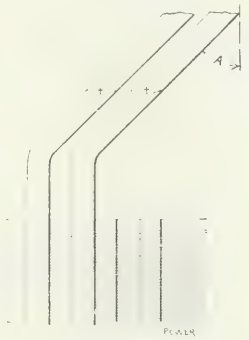


FIG. 5

(7) Shortening that part of the coil which projects beyond the core renders the end connections less liable to damage by magnetic reactions such as are caused by severe short-circuits or heavy overloads, and the entire motor may be made shorter, resulting in a saving of material.

SHAPE OF END CONNECTIONS

The diamond-coil winding is in effect a two-layer winding, as the lower "sides" of the coils form one layer and the upper "sides" another. As the thickness of the coils is the same in both cases, a little consideration will show that the air space between the coil sides lying in the tops of the slots is less than that between the coil sides in the bottoms of the slots, which lie on a circle of larger diameter. The angular distance between the sides or straight parts of the coils must, of course, always equal the thickness of the teeth but the space between the end connections is governed by the angle which they form. The more acute this angle is, the more space there is between coils.

The factors affected by this angle were fully discussed with fractional pitch and should be carefully noted before deciding on the angle to be used. The circumference of the inner diameter of each layer of coils (radii R_i and R_o, Fig. 4) should be measured and divided by the total number of coils. The coil angle which it is proposed to use should then be laid out to scale accurately, as shown in Fig. 5, and the distance t determined by measurement. If this distance is less than the number obtained by dividing the circumference by the number of coils, there will be a space between the end connections equal to the difference between the two measurements. If the distance t is greater, however, the angle A must be made more acute, because the coils cannot be placed in the slots with the end connections side by side; they will pile up on one another. If the angle A is such that there will be space between the coil sides in the inner layer (smaller circle) there will be a slightly larger space between the coil sides of the outer layer, but as a rule this difference is so slight as to be negligible.

On stators of small diameter and few poles, however, the difference between the diameters of the inner and outer coil circles is a large enough proportion of the stator diameter to render it impossible to design a coil having the same angle of end connections in both layers, especially when the long pitch due to the few poles is considered. In such cases it becomes necessary to calculate the angle for each layer separately, and an unsymmetrical coil results; this is no disadvantage for a form-wound coil, however.

LENGTH OF COIL SIDES

The two straight portions of each coil lying inside the slots, called the "sides," are usually made of the same length, but the coils will fall into place more easily if the inner "side" (the one which is put in the slot last) is made longer than the other "side" by an amount equal to twice the thickness t (Fig. 5). This will allow the last few coils of the winding, which always are the most troublesome, to be inserted much more easily, because the under "side" of the coil will pass under and through the upper "sides" of the other coils without raising them out of the slots any more than enough to clear the height of the coil.

MAKING THE FORM

A consideration of the preceding explanations should enable the reader to decide on the exact coil proportions required, and even if a sample coil be at hand for a guide, it will be to the reader's advantage to check up his coil for the sake of future jobs when he may not be so fortunate.

The laying out of a diamond coil appears very simple and it was once the writer's misfortune to lay out a form with this delusion in mind, resulting in a beautiful-looking set of coils which, alas, went into the scrap copper box because they would fit nowhere else, owing to the hastily designed end connections.

The form must be made of some hard, non-warping wood, preferably teak. Lignum vitæ is also excellent, but, owing to the cost of working it, should not be used except for a form likely to receive a great deal of use. Two pieces of wood will be required, each about ⅛ in. thicker than the height of the coil and as wide as its extreme width. The length must exceed the extreme length of the coil by about an inch, all dimensions being taken with the coil flattened out.

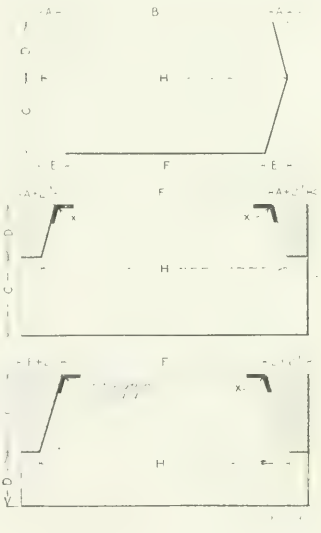


FIG. 6. LAYING OUT COIL FORM

The pieces of wood must be surfaced off perfectly true and parallel on the edges, after which the exact dimensions of the coil must be laid out on them with a sharp pencil, as shown in Fig. 6, which also shows the pieces to be cut out of the corners. The form may then be cut out, preferably on a band saw, to insure square edges, and the pieces sawed out

must be preserved, as they may be required later. All edges of the form must be sandpapered dead smooth and the corners at *X*, *X* in Fig. 6 slightly rounded to prevent damage to the cotton covering on the wire. As the wire tends to sink into the wood at these corners, due to the tension employed in winding, the shape of the form will be gradually changed; therefore, when the number of coils to be made will warrant the additional expense, pieces of fiber should be inserted at these points, as shown in Fig. 6.

Producing the Coil Offset

When the coils are in place in the motor it is desirable that there be an air space between the top and bottom layers of end connections for ventilation and improved insulation where the coils cross each other. This air space is obtained by giving an offset to the twists in the end connections; this offset is shown in Fig. 7; it is obtained by inserting a piece of fiber between the two halves of the form. The thickness of this sheet of fiber ranges from ⅛ in. for the coil of a 2-hp. motor to ⅜ in. for a coil for a 50-hp. motor, ¼ in. being a good average for motors of 5 to 20 horsepower.

In order that the coil may be removed from the form it is necessary that the fiber sheet be in halves, and each half attached to half of the form, as shown in Fig. 8. The sheet should be cut to the same length as the form but should exceed the width of the form by about ½ in. in order that a small ledge will be formed on which the coil may be wound. The form must next be lined up so that the edges will stand open enough to admit the wire to be used, as shown in Fig. 9, and firmly clamped in this position at both ends.

Bushings, Etc.

The form must be held together by two ½-in. bolts closely fitting the holes drilled for the purpose, and as more or less hammering will be necessary during the subsequent winding and shaping of the coils, it is advisable to drill the holes large enough to take bushings made of brass tubing of ½ in. inside diameter. These bushings must be a tight fit in one half of the form and a close sliding fit in the other half. A third bushing should be inserted at the exact center of gravity of the form to serve as a bearing for the mandrel upon which it will revolve during the winding of the coil.

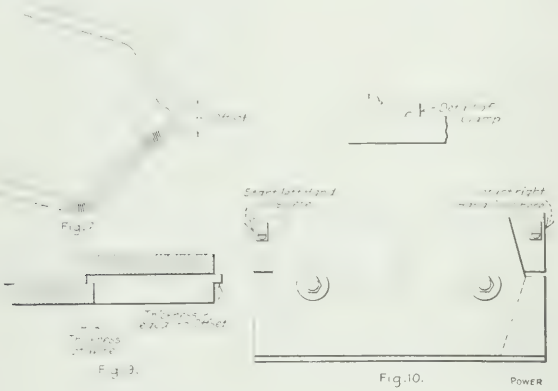
Two hacksaw cuts must be made on each side of the form about ¼ in. from the ends of the straight parts of the coil. These sawcuts are to permit the binding wires, which hold the coil in shape after its removal from the form, to be inserted under the wire.

A small fiber clamp held by a wood screw and copper burr must be attached to the form to hold the beginning end of the wire in each coil. This clamp must be on the end of the form corresponding to the terminal end of the coil, and where right- and left-hand coils are used in the same motor the clamp must be transferred to the opposite end, after half the number of coils is wound, as shown in Fig. 10.

When the coils are symmetrical, it is immaterial to which side of the form the clamp is attached, but when an unsymmetrical coil is to be wound the clamp must be fastened to the side of the form having the longest straight portion or coil "side."

The *end* to which the clamp is fastened determines the "hand" of the coil, the *side* to which it is fastened governs the location of the splice between elements of a coil, as will be described later.

The bushings, sawcuts, clamp and other details are clearly shown in Fig. 8, a close examination of which is advisable before proceeding to make a form.



Figs. 7, 9 and 10

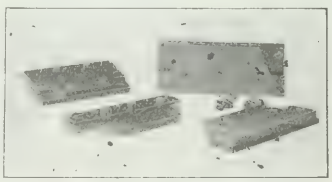


Fig. 8. Coil Forms

Use of Corner Blocks

The small form shown at the rear left of Fig. 8 is fitted with small corner blocks at each end which are missing in the other forms shown. These blocks may be made out of the pieces sawed out of the corners of the form, which were put aside, and their use will greatly facilitate the winding of small coils having relatively many turns of fine wire.

The use of corner blocks is recommended for all forms using wire smaller than No. 14 and requiring more than seven turns per layer. When heavier wire and fewer turns are required, the cotton insulation is liable to abrasion, owing to the difficulty of forcing the comparatively stiff wire into the narrow slots between the form and the corner blocks.

As the corner blocks give the proper twist to the V-shaped ends of the coil, their omission necessitates the formation of this twist by other means. The simplest method is to wind the coil rather loosely and press each turn into approximate shape at the twist with the thumb. After all the turns are on the form the accumulated slack may be worked toward the ends of the coil by means of a small fiber block and a mallet.

Beginning at the middle of the coil "sides" and working toward the ends the coil is gently driven into shape against the edges of the form. After one or two practice coils have been wound, the proper tension to give during the winding operation will be determined easily, and once the knack is caught it will be found that twice as many coils can be wound in a given time without corner blocks as with them.

"To a large extent," said Frank W. Smith, secretary of the United Electric Light & Power Co., of New York City, "the prosperity that you and I enjoy is due to the passing of individualism and to the present-day spirit of coöperation. Without organization, the best effort is not possible of attainment. It means betterment for you individually and collectively; it means improved conditions, greater success and a sure future for your company; for, without a loyal force 'laboring together with others for a common end,' great success and prosperity to any business enterprise must fail."

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

A German Peat Gas Power Plant

By Paul C. Percy

At the East German Exhibition which was held some time ago at Posen, a complete peat-gas power plant in full operation attracted a great deal of attention. The producer was the Heinz apparatus, described last June in Power, and the engine was a horizontal single-cylinder, double-acting machine, designed especially to work on the variable quality of gas characteristic of peat gasification.

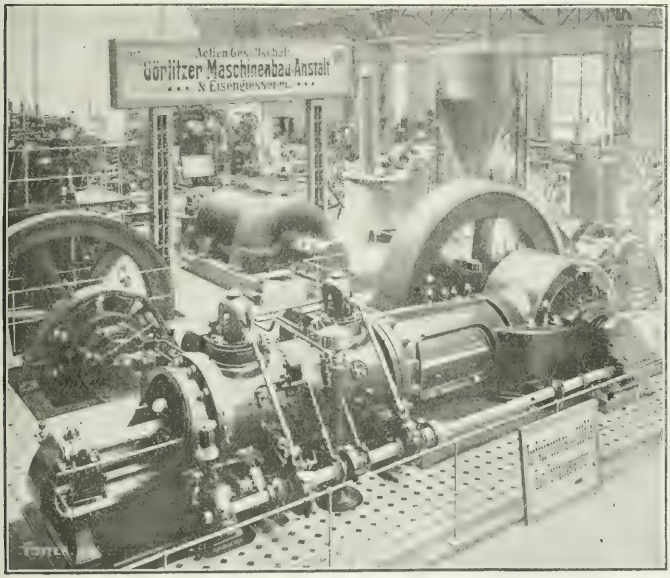


Fig. 1. Gorlitzer 300-hp. Peat-gas Engine

Fig. 1 is a view of the engine in the exhibition hall. As the picture clearly indicates, the engine is very "stockily" built. This construction, together with a relatively moderate compression pressure, is employed in order that, even with the high explosion pressures produced by especially "snappy" gas, the parts subjected to the explosion stresses may have a margin of safety. The inlet and exhaust valves of one end of the cylinder are operated from a single eccentric on the layshaft (the engine works on the four-stroke cycle), an arrangement now quite common. It will be noted that the American practice of using side-crank construction is followed instead of the old German center-crank form. Ignition is effected by means of the oscillating type of magneto and make-and-break igniters tripped by linkage from the magneto shafts. An individual magneto is provided for each combustion chamber.

The engine is rated at 300 hp. and was used to drive an electric generator which supplied current throughout the exhibition hall.

Fig. 2 is a sectional view of the producer outfit. The gas generator may be considered as in the down-draft class, but differs in several important respects from the ordinary down-draft type in general use. The air is taken from the pit beneath it, which also contains the scrubber water and the gas-delivery pipe *D*. Part of the air is drawn through the pipe *A* and the superheater *B* into the upper part of the fuel column, whence it must travel down through the fuel bed in order to reach the gas outlet below. The remainder of the air ascends through the space between the outer and the inner shells of the generator, absorbing radiant heat, and under normal conditions it enters, through the valve *C* at the base of the purge pipe *F*, the combustion chamber above the fuel bed.

Gasification of the fuel takes place in one direction only, and the gas is withdrawn from the center of the combustion chamber below. The air, instead of traveling along the walls of the generator, is forced to enter the inner strata of the fuel bed. The heavy gases produced in the upper layers of the fuel bed are forced to pass through the incandescent zone below, where they are

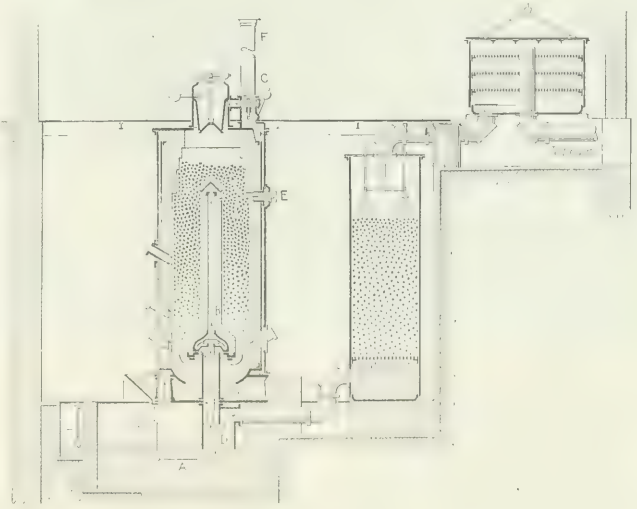


Fig. 2. Sectional Elevation of Heinz Producer

split up and converted into light and permanent gases.

If the water content of the peat exceeds certain limits, somewhere around 40 per cent., an auxiliary process is employed temporarily by starting a second combustion zone near the top of the fuel bed. This is done, by opening the pipe *F*

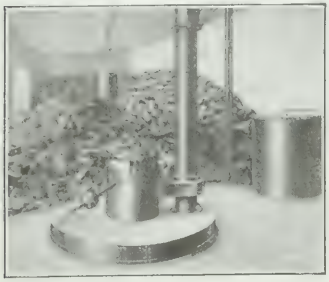


FIG. 3. THE CHARGING FLOOR

and the auxiliary air-inlet valve *E*, as soon as the attendant notes that the fire on top of the fuel column is disappearing. The valve *C* then closes automatically and the air which is preheated in the space between the shells enters the fuel bed directly through the valve *E*. Thus combustion is started at the level of *E* resumed. By the temporary employment of this expedient, fuels of very high water content can be gasified. Of course, there is a moisture limit, for in peat containing 80 per cent. of water the 20 per cent. of combustible would be only sufficient to vaporize the water and no combustible gas could be produced. With the auxiliary process the consumption of fuel per horsepower-hour becomes somewhat greater than normal, but the operation is very simple and free from troubles.

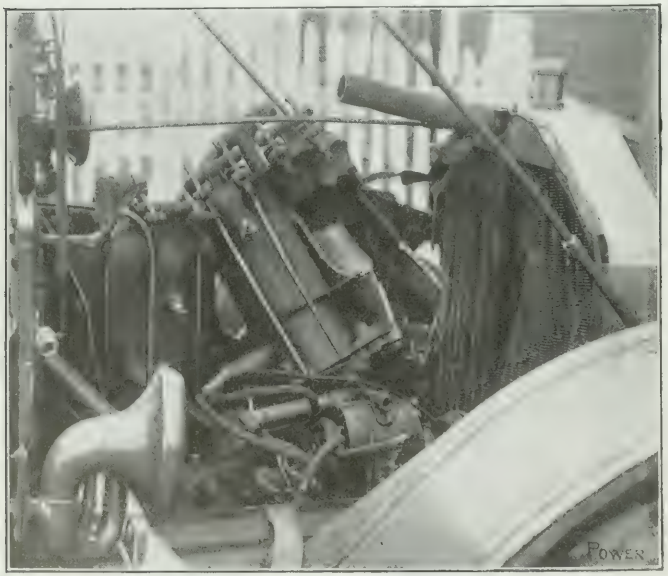
In this producer all the gases emanating from the scrubber water are drawn up with the air into the combustion chamber and destroyed. The gas produced is very clean.

Fig. 3 is a view of the charging floor of the producer exhibited at Posen. The simplicity and cleanliness are obvious from the picture. The producer and engine were built by the Görlitzer Machine Works, Görlitz, Germany.

LETTERS

What Caused the Explosion?

The accompanying picture gives a view of an automobile engine that was wrecked by the bursting of the front cylinder. This was a four-cylinder engine of about 35 hp. and had been in



WHAT CAUSED THE EXPLOSION?

both ways, the up-draft being provided by the pipe *F* serving as a chimney and the down-draft by the suction of the engine. As soon as incandescence is reestablished on top of the fuel bed the purge pipe *F* is closed off and the valve *E* shut; the normal process is thereby excellent working order. The car had not been taken out of the garage for three or four days before the explosion, and it can hardly be supposed that anyone could have tampered with the engine. As can be seen, the front cylinder is literally blown to pieces; the cylinders being cast in pairs, No. 2 cylinder was broken from the crank case. A piece of casting was blown practically through the radiator, a large piece of casting was blown through the right-hand mudguard, the wind shield was shattered, and the bottom half of the crank case was broken into a hundred or more pieces.

When the engine was started up there was no one present except the man who started it, and he was perfectly familiar with it. His only explanation of the accident is that he attempted to start the engine as usual and only made a couple of turns of the crank when the explosion occurred.

I can offer no solution of the accident, nor has anyone who has looked at the engine. I would like to have other readers give their opinions as to the cause of the explosion. The gasoline tank contained some ten or twelve gallons of gasoline when the explosion occurred, but it was not ignited. Most of the remaining gasoline was used in another four-cylinder engine without giving any indication of unusually explosive qualities, although from the results of the explosion one would think that a few sticks of dynamite had been put into the front cylinder and then fired.

L. EARLE BROWNE.

Roundup, Mont.

Was It Too Early Igniter Timing?

While operating a 10-hp. horizontal gasoline engine in Canada last summer, I had a peculiar experience. I started up the engine one morning and when it had made a few explosions and got fairly well started, turned the ignition timer to the running position, giving early ignition. When I did so the engine was practically wrecked, the base being diagonally broken on each side and two ¾-in. studs at the head end, holding the base to the sub-base, being sheared off. The crank end of the cylinder, with half of the base, was raised, thereby bending the connecting-rod and cracking a triangular piece out of the piston. The valve and igniter settings were correct; I had gone over them shortly before starting up.

Clamps were put on each side of the base, the piston inverted until a new one could be obtained, and the engine adjusted and operated a week while I was there with fairly good satisfaction.

I would like to know if any other reader has had the same experience or if anyone can account for the wreck, except by saying that the maximum explosive force occurred exactly on dead center and there was not enough momentum to carry the flywheel over, so the weakest part gave way.

R. E. WALL.

Beloit, Wis.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Compressor Water Jackets*

By Edward N. Friedmann

If is certainly of interest to know what influence the water jacket exerts and to know the conditions under which it is most useful; also whether it were best at times not to use the jacket. What I would like to see established is some simple rules showing the operating engineer that under certain conditions it is best to run all the water he can through the jackets, and, of course, at the lowest temperature available; also, under what conditions he should stop the flow of water to the jacket.

While investigating this problem, not having access to an experimental plant, I was limited for data to the reports of tests made at the works of the York Manufacturing Co., York, Penn., and of the Eastman Kodak tests. In reading the discussions and claims of the participants in these tests, following their completion, it may be seen that the manipulation of the water jacket was one of the bones of contention, but ever since those tests, now several years ago, the matter has rested so far as data were concerned, and no additional facts have been established or published to my knowledge, and I must, therefore, confine my observations to the material then available.

While studying the data mentioned, I found that certain conditions affected the use of the water jacket differently in the single-acting and the double-acting compressor, making the influence of the water jacket favorable or unfavorable, according to circumstances.

In a double-acting compressor, during each stroke, there is suction on one side of the piston and compression on the other, while in the single-acting compressor, during the up stroke, there is suction on the bottom and compression at the top; but on the down stroke only gas passes from the under side of the piston to the top, without either suction or compression. During this down stroke, which may be called the "intermediate" stroke for want of a better expression, cooling or heating takes place according to whether the mean temperature of the jacket water is below or above the temperature of the ammonia inside of the compressor. Since there is no intermediate stroke in the double-acting compressor, no such cooling or heating can take place.

Now, if the mean temperature of the jacket water were above that of the ammonia, the result, of course, would be a rise in the temperature of the ammonia, and this, in my opinion, was the case at the Eastman Kodak test No. 3, resulting in a loss. By stopping the water circulation this loss was avoided, entirely in accordance with the result of the test for capacity.

If this line of reasoning is correct, the following rules suggest themselves:

1. Run plenty of water, at as low a temperature as available, through the water jacket, in order to maintain a low mean temperature in the jacket.

2. Since the larger the diameter of compressor the smaller the amount of inside superheat (meaning the heat imparted to the gas by the cylinder walls) the greater is the chance to heat the ammonia by the jacket water. It is at times, for instance in summer, best not to use the water jacket on large compressors, say of 18 to 24 in. in diameter, but to use liquid ammonia injection instead. In the case of smaller compressors, say 12 in. and less in diameter, I consider the water jacket a very good thing, effecting a greater cooling than is possible in the double-acting compressor not having this intermediate stroke.

As an illustration, consider the following three examples, taken from tests of a York single-acting compressor:

Test No. 1

Test made by York Manufacturing Co. on machine having two 12½x18-in. single-acting vertical compressors:

Ammonia discharge temperature, 213 deg. F.

Ammonia suction temperature, 19 deg. F.

Temperature at end of suction stroke, 72 deg. F.

Mean temperature of jacket water, 63 deg. F.

Temperature difference between jacket water and ammonia, 9 deg. F.

Inner surface of compressors and heads equals 11 sq.ft.

$$11 \times 9 = 99$$

hence the cooling accomplished during the intermediate stroke was 99 B.t.u. per minute. In this case the water jacket was beneficial to the extent indicated.

Test No. 2

Test made by York Manufacturing Co. in Rochester on machine having two 15x 22-in. single-acting vertical compressors:

Ammonia discharge temperature, 216 deg. F.

Ammonia suction temperature, 15 deg. F.

Calculated temperature at end of suction stroke, 50 deg. F.

Observed mean temperature in jacket, 68 deg. F.

Temperature difference between ammonia and jacket water, 9 deg. F.

Compressors delivered 311.4 lb. of ammonia in 15 min.

Inner surface of compressors and heads, 17 sq.ft.

$$9 \times 17 = 153 \ B.t.u.$$

per minute, which is the heat exchanged, but it may be noticed that in this case the jacket water did no cooling; on the contrary, it imparted heat, the mean temperature of the water having been higher than that of the ammonia.

Assuming the refrigeration obtainable at 500 B.t.u. per pound of ammonia, the loss equals

$$\frac{153}{500} = 0.306 \ lb.$$

per minute, or for 15 min. equals 4.59 lb.

Test No. 3

Test made by York Manufacturing Co. in Rochester on the same machine as in the second test.

Ammonia discharge temperature, 250 deg. F.

Ammonia suction temperature, 16 deg. F.

Temperature at end of suction stroke, 59 deg. F.

Water still, no circulation. Compressors delivered 315.65 lb. of ammonia per 15 min.

Adding the above 4.59 lb. to this gives 320.24 lb. The difference, which is extremely small, may be explained by the fact that in test 3 the suction temperature was higher and the suction pressure slightly lower than in test 2.

Test No. 4

Test of 21-in. single-acting York compressor at Ebling's brewery, New York City:

Ammonia discharge temperature, 279 deg. F.

Ammonia suction temperature, 6 deg. F.

Temperature at end of suction stroke, 40 deg. F.

Mean temperature of jacket water assumed at 90 deg. F.

In this case the difference between the ammonia and jacket water was

$$90 - 40 = 50 \ deg. \ F.$$

and, owing to the large surface of these compressors, the heating was consider-

*Excerpts from paper read at the New York meeting of the American Society of Refrigerating Engineers.

able, and if no water jacket had been used the test results would have proved more favorable than they did.

The conclusions I have come to are as follows: It is of great importance that these questions, as to when a water jacket is an advantage or a drawback, be settled by the manufacturers who are in position to have accurate tests made in their test plants, for it seems obvious that the construction of the compressor should be suitable for each particular case. As for practical reasons this is not feasible; the manipulation of the water jacket should be modified in accordance with the conditions met with in practice. With large compressors, say from 18 to 24 in. diameter, and where the cooling water available is of high temperature, such as 70 to 90 deg. F., which is often the case under summer conditions, the water jacket is not only of no benefit, but rather a detriment, while under the same conditions with small compressors, say from 12 in. diameter down, the water jacket will be an advantage.

It is regrettable that the tests by the manufacturers have usually been made under abnormal conditions, the cooling water being what may be termed "winter" water, while the condenser pressures were artificially made to correspond with summer conditions. Thus, the compressor is surrounded by colder water than would be the case under ordinary summer conditions, which influences both the tonnage of refrigerating capacity and horsepower; as a reduction of discharge temperature effects a corresponding reduction in horsepower, nearly all the power put into a compressor being expended in increasing the temperature of the ammonia vapor to that of the discharge.

The Gravity Feed System*

By Theodore O. Vilter

I have found in my experience in traveling around the country that a great many people believe the coils in a gravity-feed system, which is commonly but incorrectly called the flooded system, are full of anhydrous liquid ammonia. This is not true. As the ammonia boils, particles of gas are formed and they travel in a coil. With every foot of travel these particles of gas increase, so that at the end of the coil most of the pipe is filled with gas under suction pressure.

The gravity-feed system is designed for the purpose of supplying automatically each and every coil in a tank or a coil located in a chill room of a packing house or any series of coils that are of the same level, with the necessary supply of ammonia. In forcing every square inch of surface of every foot of pipe to its fullest extent, it is necessary to get the ammonia into that pipe, and this apparatus does that automatically, whereas with 12, 15, 30 or 40 coils, with a feed cock on each, the man who can regulate them satisfactorily is yet to be born. I have found this out in my practical experience in operating refrigerating and ice-making plants. The gravity-feed system in connection with the accumulator is the proper apparatus to be applied and the efficiency of the plant is increased by the use of this apparatus.

In the tank of a plate ice-making plant there are coils that have 10 in. of ice. Again, there are coils in the tank that are absolutely free from ice and as the water entering the tank on these bare coils is in all cases warmer than the ice, these pipes or coils will have to cool the water down to the ice-making temperature. Consequently, these coils require more ammonia than the others. The accumulator of the gravity-feed system accomplishes this result automatically and the engineer is not hampered by finding, when he comes on duty in the morning, that one coil has 2 in. of ice, another 3 in., and another 4 in. The ice forms absolutely uniform. In the plate ice plant this can be noticed, whereas in the coils of a can ice tank it is not apparent. This is why in a great many cases the efficiency of a can ice plant is increased by the addition of the gravity-feed system to existing coils.

When installing the gravity-feed system care should be taken that the accumulator is placed above the top of the coils so that the liquid may have sufficient head to enter the coils. The weight of the liquid will form a very low pressure in a tank where the cans are only 2 ft. deep. It is improved a bit with 300-lb. cans, and still more with 400-lb. cans, and much more when a plate ice plant has a tank 9 or 12 ft. deep.

Care must be taken that the liquid pipes run at an angle from the accumulator to the headers of the tank, and that the pipes are covered if they pass through a warm room in order that the ammonia may be kept from boiling as much as possible. The pipe is set at an angle in order to allow the gas that is liable to evaporate to pass back into the accumulator without retarding the flow of the liquid.

In a certain plant in the East equipped with a gravity-feed system, there were three ice tanks with three inlets from the same accumulator. The liquid-supply header was horizontal and in one tank to which it raised 9 in. it was possible to make but very little ice. The liquid header was in a warm room and in the hot summer days, of course, the ammonia boiled a great deal. The gas formed retarded the flow of liquid to the coils and reduced the output of ice.

*A paper read before the Practical Engineers' Association, in Houston, Tex.

A Floating Cold Storage Plant

A new venture which bids fair to revolutionize the methods of handling and marketing fish is to be tried by the Gorton-Pew Fisheries Co. The steamer "Alcona" is being equipped with a big cold-storage and freezing plant so that it may cruise about the various ports on the west and south coasts of Newfoundland, securing fish of all kinds, freezing and preserving them, and later shipping them from North Sidney. To help along the scheme, the Newfoundland government will allow all coal needed for operating the cold-storage plant to be admitted free of duty while the steamer is in Newfoundland waters.

The "Alcona" is of 1200 tons gross and has, in addition to the usual engine equipment of about 350 hp., two 30-ton absorption refrigerating machines which give a daily freezing capacity of 40,000 lb. of fish. Over 75,000 lb. can be spread over the freezing coils at one time. This unusual capacity in the refrigerating rooms is the result of supplying 30,000 linear feet of 1¼-in. pipe with calcium brine.

So far as is known, it is the only vessel afloat today in any part of the world carrying the absorption type of refrigerating machinery. By using vertical tubular generators, absorbers and condensers the equipment occupies very little space.

The plant was designed and is being installed by Mr. Palson, a builder of ice and cold-storage machinery at Gloucester, Mass., and the apparatus was built at the plant of the Robb Engineering Co., Ltd., at South Framingham, Mass.

The two stills or generators are 48 in. in diameter, with heavy cast-iron dished heads fitted with stuffing-boxes through which the pipe connections are made to the various coils within. The absorbers and condensers, also vertical, are 48 in. in diameter; each has one hundred and sixty-three 2½-in. tubes 7 ft. long. These were especially designed so that the tubes could expand at their upper ends and take care of any difference in expansion, which might occur between the tubes and the shells. The tubes are of extra-heavy gage, and because of the action of ammonia each tube was highly polished in a lathe so that the surface would be perfectly clean and make complete contact, thus avoiding the chance of any foreign matter getting between the metal surfaces, which would soon be eaten out by the ammonia. Designed for 150 lb. working pressure, these vessels were tested to 300 lb. pressure before leaving the shop.

All the ammonium sulphate used in Norway is supplied by four of the principal gas-works in that country.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROBT. MCKEAN, Sec'y.
505 Pearl Street, New York.
1221 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E.C.
Union Haus London 71 Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 30,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Status of the Boiler Horsepower

The boiler horsepower was originally what its name implies, the amount of steam required by a then prevalent type of engine for the development of one horsepower for one hour. Being based on transient conditions, it soon lost this connection with engine performance and became simply an arbitrary or conventional unit of boiler output. In the progress of steam engineering there has been a continual change in the relation between boiler rating and engine rating.

The function of a boiler is to absorb heat from the fire, putting it into water and making steam; therefore the unit of boiler output is essentially a thermal quantity. Taking the heat to vaporize one pound of water at 212 degrees as a sort of larger heat unit, the boiler horsepower is equivalent to 34.5 of these units, or to about 33,460 B.t.u. per hour.

Twenty years ago the best pumping engines were cutting their heat-input requirement to less than 14,000 B.t.u. per horsepower-hour; now they run below 12,000. Since the year 1900 there have been many records of engines in power service working within this same range of heat supply. In the design of a big plant, a boiler rating equal to half the engine rating has long been considered ample, giving margin for a reasonable layoff of boilers for cleaning and repair. The best records from big steam turbines show a consumption of only about 11,000 B.t.u. per estimated indicated horsepower-hour, so that one American boiler horsepower can produce three engine horsepower or nearly two kilowatts of electrical output.

Besides this lowering of heat required by the machine, there has been a decrease in the boiler surface considered necessary for a given heat transfer. The common allowance of ten square feet to the horsepower implies an average transfer rate of about 3350 B.t.u. per square foot per hour. Locomotive boilers commonly work at around sixty-five per cent. efficiency when conducting 5000 B.t.u. per hour, and are often pushed to as much as 12,000 or even 15,000 B.t.u., although the efficiency then falls to the neighborhood of forty-five per cent.

There is now a strong tendency to burn more coal under stationary boilers and get a bigger capacity, and experience has shown that the drop in efficiency is small. The installation of additional furnaces under the boilers at the Interborough power house several years ago was a pioneer example. The Detroit tests, recently reported to the American Society of Mechanical Engineers and published in our issue of Dec. 5, are another striking illustration. In these tests the rate of heat transfer varied from 3400 B.t.u. at eighty per cent. efficiency to 6700 at seventy-six per cent. This means that with big boilers and turbines good economy can be maintained when three square feet of heating surface are carrying one kilowatt of generator output. It is a long step from a 300-horsepower battery of boilers with a 300-horsepower engine to one boiler of 2400 horsepower rating which carries 8000 kilowatts.

The Value of Compression

As an interesting research for schools with steam-engineering laboratories, we suggest a series of tests to determine the effect of compression upon the steam consumption of an engine.

It is not a new subject. Extremely painstaking work was done upon it at Liége by Prof. Dwelshauvers-Dery, years ago (see POWER of June 28, 1910), and other tests and discussions have been published. But it is impossible from any data of which we know to draw efficiency curves of the same engine with different ratios of compression. When the compression is changed, either the load or the ratio of expansion changes at the same time, and the effect may not be due entirely to the change of compression.

It would be very illuminating if a series of tests could be made with an engine the valves of which were set for no compression, determining the steam

consumption of various loads per indicated and per brake horsepower, and with no variable but the load. Let these be plotted in the usual efficiency curves with the Willans line of total steam consumption added.

Let this series of tests be repeated for various degrees of compression, with the same pressure and quality of steam, the same speed; in fact, with all conditions as nearly as possible reproduced.

Will the efficiency curve with the greater degrees of compression lie above or below that with none?

Will they parallel or cross it?

Will the Willans line change its angle, and especially will it come nearer to the intersection of the coördinates, indicating diminished internal losses?

How will the ratio of the brake to the indicated horsepower be affected? This might be studied in connection with inertia-pressure diagrams, showing the effect of various degrees of compression upon the bearing pressure and friction.

Will some of our laboratories which are looking for directions in which to direct their activities consider the suggestion?

Misuse of the Term "Rotary" Engine

Of recent years, since the commencement of the now quite general adoption of the aëroplane by the more daring of our wealthy young men, several so called rotary engines have been evolved which may be said to be quite satisfactory, as far as that adjective can be applied to present-day aëroplane engineering. The majority of these engines are of the Gnome type, but whether they justify the use of the qualification rotary is open to serious question.

This is not such a silly-season sort of topic as it may appear to be at first blush. Aëronautics is a new science. Then let it take lessons from the older sciences and be careful how it picks its technical terms and expressions. An ill applied term once adopted and standardized by continuous use can be effaced and replaced only by superhuman efforts on the part of the heads of the profession. Endless misunderstanding and misconception were caused by the first definition of "boiler efficiency" in steam engineering. This term was made to take into account the furnace, the grate, the quality of fuel, etc., and it embraces all these factors when referred to now. Obviously, if "boiler efficiency" were what the two words plainly indicate, it would deal only with the capacity of the boiler itself to absorb heat and transfer it to the water within it, varying only with the design as regards construction, materials, heating surfaces, thickness of plates and other factors. Numberless other examples could be given of similar cases in which the loose application and misuse of a term at the beginning of a new science has stuck, to be misunderstood by each successive generation of students. It would be a pity if the future students of aëronautics should be hampered by the adoption of misnomers.

A lexicographer defines reciprocating engine as "the common form of engine, in which the piston and piston rod move backward and forward in a straight line, absolutely or relatively to the cylinder, as in oscillating engines. The term is used in contradistinction to rotary engine," which is found to be "a form of steam engine in which the piston rotates in the cylinder or the cylinder upon the piston. The varieties are numerous, but in practice rotary engines are not found to be any more economical than the reciprocating engine with crank attached." The latter part of this definition certainly presupposes the absence of cranks in rotary engines. Equally certainly, this definition was written in the days before the reign of the steam turbine and equipment of similar construction.

Webster's "International Dictionary" gives a similar definition of a reciprocating engine, but says that in a rotary, or rotatory, engine, "a piston, vane or the like is constrained to move in a circular path, thus obviating the necessity for a connecting-rod and a crank." It also gives the following description of a rotative engine, "an engine in which the reciprocating motion of the piston is transformed into a continuous rotary motion."

Another dictionary, however, seems to give the most emphatic definition of a rotatory, or rotary, engine as an engine in which the piston rotates in the cylinder or the cylinder upon the piston "without the intervention of reciprocating parts." It also refers to steam acting directly on "surfaces rigidly connected with the shaft to be set in motion."

Now the Gnome engine and its contemporaries are certainly not rotary engines in the same sense that a steam turbine is a rotary engine. A steam turbine consists broadly of two parts, a stator and a rotor the first is stationary and the latter in rotary motion. A so called rotary aëroplane engine of the Gnome type has also a stator and a rotor. The crankshaft is the stator and the rest of the engine is the rotor. So far, so good, but there are "wheels within wheels" in this case. The Gnome engine and its like are also reciprocating engines. For all their seeming "rotariness," to coin a word—they hide away pistons which reciprocate in their cylinders. Without the reciprocation of these pistons the mechanisms termed "rotary engines" would no longer be prime movers; they would be locked in such a case.

A perusal of the foregoing definitions makes it plain that no engine with reciprocating parts may be justifiably called a rotary engine. Gnome and similar engines *do* contain reciprocating parts; hence they cannot be rotary engines. They are reciprocating engines certainly, but the term "reciprocating engine" has been standardized to mean one particular type of reciprocating engine, and some other name should therefore be found for the Gnome type of engine which will convey the impression that, while they are reciprocating engines, they are by no means of the usual type of this class. The most suitable name appears to be "rotative engine," in which "the reciprocating motion of the piston is transformed into a continuous rotary motion."

The term "failure" has come to be loosely used as synonymous with disaster, etc. A piece of metal "fails" under such and such a stress in the testing machine. One speaks of a "flywheel failure" although the exploded wheel may have been racing at a speed far in excess than that for which it was designed. It was in this loose sense that we referred to the "failure of a condenser" in our issue of December 19. As was made plain in the article, the condenser was subjected to an internal pressure which it could not be expected to withstand and that it "failed" or exploded under such abnormal conditions is no reproach upon the apparatus or its makers.

The Otis Water Purifying System

The accompanying engravings illustrate a system which has just been brought out by the Stewart Heater Company, Buffalo, N. Y., for removing scale-forming materials and other impurities from boiler-feed water. The process is simple. It consists of heating the water in one vessel and passing the heated water through a filtering bed contained in another vessel. The high temperature (300 degrees or over, according to the pressure carried in the boiler) attained in the heater is said to precipitate all of the scale-forming materials, some of which deposit on the heater surfaces and some remain in suspension in the water. The water is passed through the filter to remove such matter as remains in suspension in it.

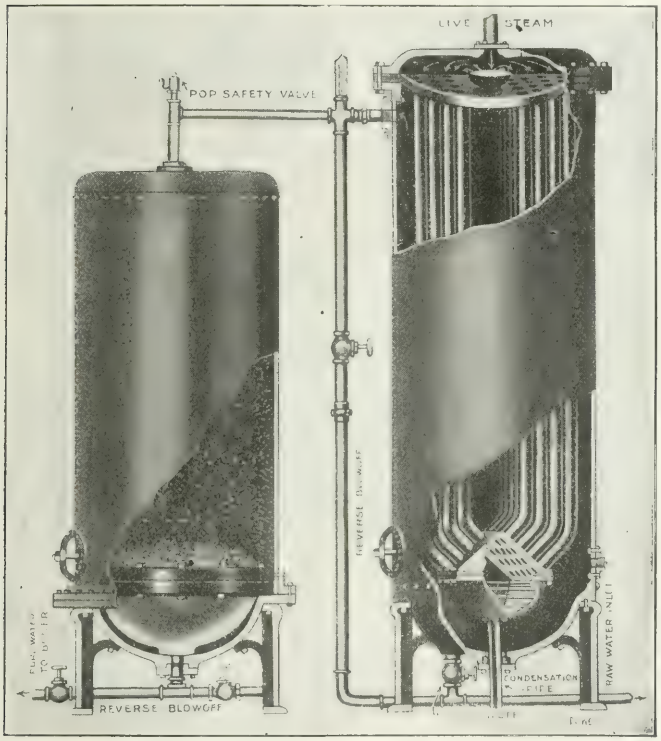


FIG. 1. THE OTIS WATER-PURIFYING SYSTEM

Referring to Fig. 1, the right-hand member is the heater, the construction of which is clearly shown. Live steam at boiler pressure is admitted at the top and fills the tubes. The water enters from the supply pipe or the ordinary feed-water heater at the "raw water inlet," near the bottom of the shell, and fills the shell up to the transfer pipe leading over to the filter. The heated water passes through this pipe and down through filtering beds of emery supported on perforated copper plates or trays, emerging from the filter tank at the bottom and passing to the boiler-feed main.

At intervals the deposits of foreign matter on the heater tubes and in the filtering beds are blown out by admitting cold water at the outlet of the filter tank and running it backward through the system. The cold water causes the heater tubes to contract and the scale which has deposited on them is thereby cracked off, according to the maker's explanation.

Fig. 2 shows the method of piping the system that is advocated by the maker. The feed-water supply is taken from the pipe *A* and normally flows into the heater through the valve *I*, the bypass valve *B*, back-flow valve *C*, relief valve *D* and blowoff valve *E* being closed. The cleansed water passes from the filter tank to the boiler-feed main through the pipe *F* and valve *G*. To cleanse the system, the steam supply is first shut off (valve *S*) and the water-inlet valve *I* is closed. Then the valve *D* is opened to let out whatever steam may be in the heater, and the valves *C* and *E* are opened. The former admits cold water to the bottom of the filter tank and the latter allows the water to discharge from the heater to the drain. Then the valve *D* is closed in order to force the backward flow of water from the filter tank to go through the heater. This back flow is continued until clear water comes out of the discharge pipe. While the cleansing process

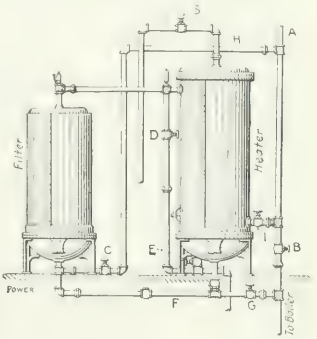


FIG. 2. METHOD OF PIPING SYSTEM

is going on, water may be fed to the boilers if necessary through the bypass valve *B*. When the purifying system is normally supplied with water which has passed through a heater, it is advisable to connect the back-flow pipe *H* with a cold-water supply instead of the feed-water supply, because cold water is preferred for cleansing the system.

Multiported Safety Exhaust Outlet Valve

An improved type of exhaust-outlet valve has been designed by the Harrison Safety Boiler Works, Seventeenth and Clearfield streets, Philadelphia, Penn.

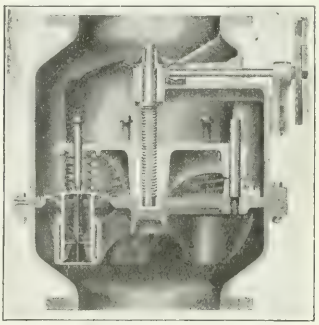
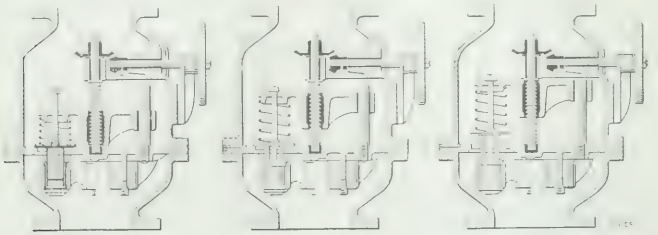


FIG. 1. COCHRANE MULTIPORTED EXHAUST OUTLET VALVE

An interior view of this valve is shown in Fig. 1. This valve has been designed for the purpose of discharging a large amount of steam at low pressure in a short time and also to keep the lift of the several valve disks as small as prac-

ticable and to operate without pounding on their seats.

The valve operates on the principle of the pop safety valve, in that the disks are held to their seats by springs, the tension of which can be varied within the range of the spring. When the pressure on the underside of the disks overcomes the resistance offered by the springs, the disks are forced open and the steam is allowed to escape to the atmosphere.



FULL PRESSURE VALVES IN CONTACT ONLY RAISED FOR FULL OPENING

FIG. 2. THREE PRINCIPAL POSITIONS OF PRESSURE PLATE IN COCHRANE VALVE

The valve may be described briefly as consisting of a valve deck upon which are placed a number of small valve disks, each individual disk being held closed by a spring. A water cushion or dashpot is also provided for each disk to arrest its motion and to prevent damage to the disk and its seat. Each disk may be lifted free of the seat by a stem when desired. The tension of the spring is determined by the position of a pressure plate, made adjustable by means of a vertical screw which may be turned either way by means of bevel gears connected with a horizontal shaft which extends to the exterior of the valve casing. This shaft is fitted with either a handwheel, chain wheel or a gear wheel. The valve deck is placed between the flanges of the bottom and the top castings, the latter having two or more handhole plates or doors for access to the valve deck.

From the type of valve disks used, their large number and the fact that they are made of bronze, as are also the linings of the dashpot, the probability of sticking is remote. Should one disk be deranged, all the other disks will continue in operation, and there is but a slight possibility that all of the disks of a valve will become inoperative at one time.

In the valve herewith shown, the aggregate area of the small disks is somewhat larger than the area of the inlet and outlet orifices, which provides generally an unrestricted passage for the steam when the disks are raised for exhausting free to the atmosphere.

The individual disks are small and light, and respond quickly when pressure is applied to them. The seating of the disks is retarded by a water cushion in the dashpots beneath them. The water in these dashpots is produced by the condensation of the steam.

Adjusting the tension of the spring is done by raising or lowering the pressure plate, but it is impossible for a certain pressure to be exceeded without substituting new springs; that is, when the pressure plate is down all the way, the springs are compressed to their maximum.

The three drawings in Fig. 2 illustrate the several positions of the pressure-plate and valve disks when the valve is set to the maximum back pressure. The first is set with the valve disks just touching the seat, as when only a few ounces of back pressure are required to force steam into a heater or other apparatus; a central position and finally with the valves raised to the maximum hight to allow free exhaust to the atmosphere.

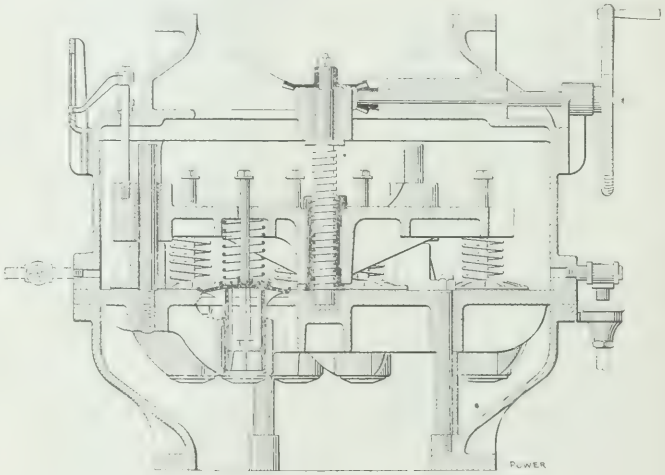


FIG. 3. OUTLET VALVE FOR VACUUM SERVICE WITH OVERFLOW TYPE OF WATER SEAL

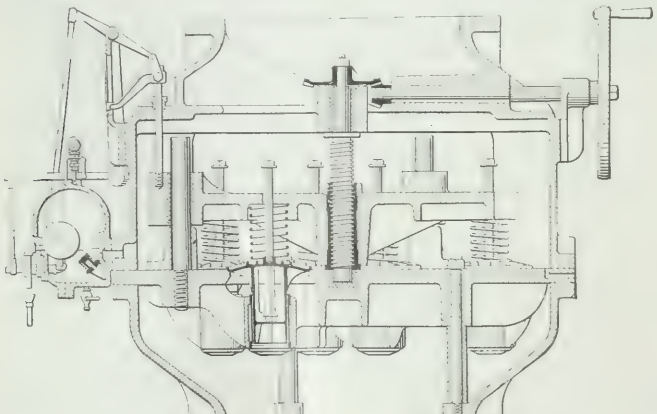


FIG. 4. VALVE EQUIPPED WITH TRAP-CONTROLLED WATER SEAL

In Figs. 3 and 4 are shown two types of back-pressure valves intended for vacuum service. They are fitted with light springs and are provided with a means of water sealing. The water seal may be of the simple overflow type, shown in Fig. 3, the water entering through the valve connected at the left and overflowing at the right, or it may be of the trap-controlled type, shown in Fig. 4, which is more economical of water, since when

the water reaches the required depth on the plate, the further admission of water is cut off by the float in the float chamber. In order to prevent waste of water when the valves are raised for exhausting free to the atmosphere, a system of levers is provided which closes a valve in the supply pipe. As may be seen in Figs. 3 and 4, an indicator is provided on the outside to show when the disks are fully raised or closed.

Sturdy Smokeless Furnace

The main feature of this furnace is the side-stoking magazine in which the grates are not only placed beneath the fuel but are on the outer side of the fuel as well. The fuel is held in place on the inner side of the furnaces by two sets of upright triangular water-tube grates which face each other in the combustion chamber.

The central compartment is covered with firebrick arches, as shown at *A*. The sides and back wall of the fuel chambers are lined with firebrick, and the floor of the combustion chamber is also so lined. The water grates are located 20 degrees apart, each set consisting of 20 upright hollow triangular-shaped bars with their narrow sides pointing inward and backward, as shown at *B*.

The fuel burns against and through the face of the upright water grates, the flame from each furnace chamber passing through the grates and impinging upon each other as they meet in the central chamber. The flames then pass beneath the central arch and along the bottom of the boiler sheet, returning to the front of the boiler through the tubes.

Air is forced into the compartment under the central combustion chamber and passes through openings to the ashpit under the grates.

The discharge pipes from the water grates connecting the top drum of the water grates with the sheet of the boiler; the intake pipe connects with the bottom drum. This arrangement produces a rapid circulation through the water grates.

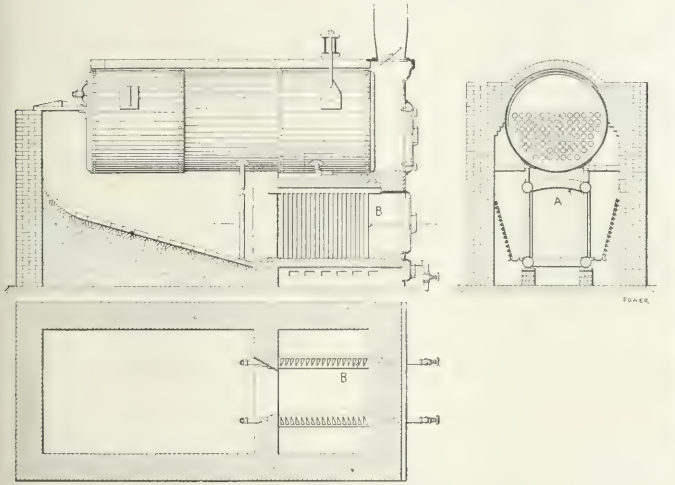
This furnace has been designed for burning any grade of coal, wood or shavings without smoke.

It is manufactured by the Sturdy Brothers, Buffalo, N. Y.

An Automatic Water Gage

When the ordinary type of gage-glass breaks, one is often forced to step lively in the effort to avoid the cloud of steam that is liberated, and the task of shutting off the connections to the glass is far from a pleasant one.

The accompanying figure illustrates the "Safeguard" automatic water gage, manufactured by the Penbertby Injector Co., of Detroit, Mich. This gage is designed so as to close automatically when the glass breaks.



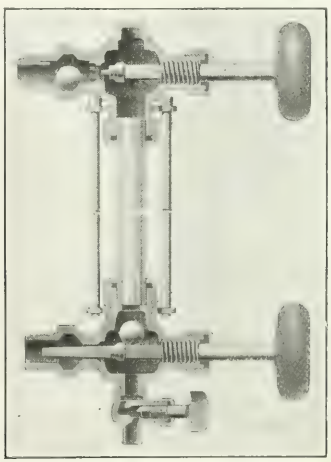
SECTIONAL VIEWS OF STURDY SMOKELESS FURNACE

Included in the lower or water arm of the gage are a stem and ball, the ball being supported upon the stem. That portion of the stem upon which the ball rides is square in shape, so as to give the ball an up-and-down movement when the handwheel of the stem is moved to screw the stem in or out. The ball, being disturbed by this movement, automatically cleanses itself from deposits, keeping its surface bright and clean so as to seat perfectly at the critical time of the breakage of the glass. Another effect of this movement is to prevent the formation of lime within the space of the ball chamber, the ball acting as a pulverizer of the deposits and not allowing such solid formation that it cannot be blown out.

When the gage stem is screwed in or out, a tongue shaped extension integral with the stem, beginning at the stem seat, rotates eccentrically through the shank of the gage to a point slightly within the boiler or column. This serves to prevent the formation of lime deposits.

The blowoff cock used in the fittings of this gage is so constructed as to be an important aid in the assembly and action of the gage, and because of its slow opening and closing movement, adds to its safety features. This has a screw-threaded stem of fine pitch which makes it impossible to open or close the cock suddenly, for when quick-opening cocks are used the glass bursts under the sudden release or formation of pressure and by the rapid change in the temperature of the glass.

The shank port in the upper arm of the gage is purposely made of extra-large area, that it may contain a ball and permit the formation of the ball seat. This seat is shaped square or hexagonal so as to prevent the tight seating of the ball. When the gage is in operation its action is promoted by the breaking of the gage-glass. This occurrence permits the pressure on the boiler side of the balls to attempt its release through the ball-seat ports, but the escape is promptly stopped by the balls finding their seats. When a new glass is tightened in, the boiler pressure is built up in the glass equally with that in the boiler. The equalization is accomplished by the steam flowing gently between the ball and its irregular seat in the upper arm. When the pressure in the glass becomes equal with the pressure in the boiler, the balls drop of their own weight and leave a clear circuit throughout the arms and the glass of the gage to the boiler or column space.



THE PENBERTHY "SAFE GUARD" WATER GAGE

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Plugging a Well

Some time ago we had occasion to move two 16x9x14-inch crank-and-fly-wheel pumps from the ground level, where they had been operating, taking their suction from two 10-inch driven wells, to the bottom of a 25-foot concrete pit, and there connect them up

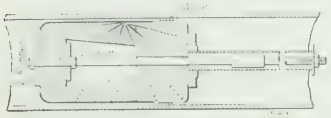


FIG. 1. THE WELL PLUG

again to the same wells and the same discharge pipe.

It was necessary, of course, to cut into each well at the proper point near the bottom of the pit and there insert a 10-inch flanged tee for the suction connection. It was found on investigation that the wells would have to be cut and threaded and flanges screwed on at a point about 10 feet below the water line in the well when not pumping.

Of course, some method of stopping the flow of water while this was being done was imperative, and it was up to us to devise one.

After rejecting such schemes as a bean bag, a piston with rubber rings, etc.,

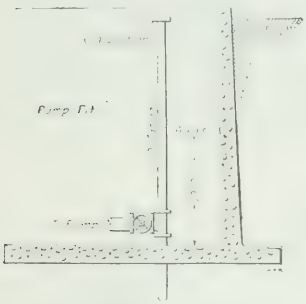


FIG. 2. LOCATION OF NEW PUMP SUCTION

the device shown in Fig. 1 was made. A piece of pine 18 inches long was turned to 9¾ inches diameter, and a cone-shaped hole turned in one end; this hole was made deep enough to allow a cone-shaped plug to expand the outer plug to somewhat more than the diameter of the well.

The annular part of the outer plug was cut with eight radial saw cuts to allow for expansion, and a dozen turns of heavy wire were made around the other end and soldered, which effectually prevented splitting.

A piece of ⅛-inch sheet-rubber packing was tacked around the outside, extending well above the saw cuts.

A plug was made to fit into the tapered hole, with an iron washer on each side held by nuts on the 1-inch iron rod in the center.

This rod was long enough to reach above the top of the well, and had a long thread on its upper end.

A piece of 2-inch pipe was fastened by a flange to the large plug, the 1-inch rod running inside this and extending a few inches beyond.

The method of using the outfit was to lower the plug in the well until the plug was below the cutting point; then the nut on the rod was screwed up, which expanded the eight sections of the plug and pushed the rubber firmly against the well casing. The well was then cut and threaded; a flange was put on, and a tee and valve bolted in place. Then the old piece of casing was bolted on top of the tee and the plug was removed. The casing was then capped; it now acts as an air chamber for the suction pipe.

The device worked all right, only a little water leaking into the pit. It might have been improved by ⅛ inch more clearance in the diameter.

B. S. NELSON.

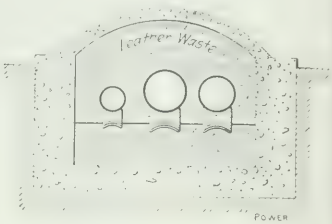
Bayonne, N. J.

Protection of Underground Pipes

I had occasion recently to cover some underground steam pipes and a description of the means taken to protect the pipes might be of interest to POWER readers.

The pipes were originally laid in plank boxes which had become badly decayed. I had the pipes dug up and a clear space left beside and under them. Then, I had about 2 in. of cement put down in the bottom of the ditch about 3 in. clear of the pipes, keeping them blocked up in the meantime. Next, I put 10-in. planks along the sides of the pipes, leaving about 1 in. clear between the planks and pipes and filled the sides back of the planks with concrete after putting iron rods with rollers at the ends of each section of plank so that the ends of the rods would be bedded in the concrete. After the planks were removed and the pipes were let down on the rollers. I had leather waste about the size of coarse sawdust packed around the pipes, leaving the top rounding full, after which I put cement mortar about 1 in. thick over the top. The idea was that the top could be easily broken up whenever it was necessary to get at the pipes.

This job proved effective, there being



SECTION OF PIPE TRENCH

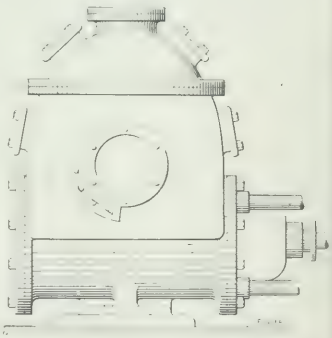
very little condensation. A section of the conduit would look something like that shown in the accompanying figure.

F. L. PERKINS.

Maynard, Mass.

Pump Cylinder Repair

I found when taking charge of a steam plant a few years ago, among other pieces of apparatus, a 10x16x18-in. vacuum pump and jet condenser, with a



SHOWING CRACK AND PATCH

crack in the water cylinder, as shown in the accompanying figure.

I learned from one of the oilers that the cylinder had been cracked about two years before; that one of the engineers had patched it, after a great deal of effort, with a large quantity of sheet packing. He succeeded in partly stopping the leak. At the time of which I speak, however, it leaked continually and seriously interfered with obtaining a good vacuum.

I had conceit enough to think I could put a patch on that place that would hold, but after repeated efforts with all the sheet packings and iron and steel cements known to me, I lost some of my conceit.

All were failures, and I was considering the purchase of a new cylinder, when I thought of the following repair: A piece of ½x2½-in. iron, 12 in. long, was bent edgeways for the patch and beveled on the inside edge to conform to the fillet on the neck of the boss. Then I drilled ½-in. holes 2½ in. apart, laid the piece on the cylinder, covering the crack as well as possible. The holes were marked, drilled and tapped for ½-in. studs, 2 in. long, regardless of where they came. Then I screwed in the studs and placed the patch in position, leaving a space of from ¼ to ½ in. I then placed wood forms plastered with clay all around the piece, leaving a hole at the highest point, after which molten lead was poured, the form removed and the nuts tightened, at the same time the patch was lightly tapped with a hammer. The pump was then started, and has been running ever since, with never a sign of a leak.

In justice to the iron and steel cements, I will say that I think that with the same method of repair the cements would have been as effective, although not as quick to set.

CHARLES W. HOPES.

Glens Falls, N. Y.

Civil Service Examination

Having read with interest many discussions in POWER of the relative virtues and vices of existing and contemplated State license laws, I believe that a brief description of the civil-service laws of Illinois might be of value to those not familiar with this class of service.

The Illinois civil-service laws govern all employees of the various State institutions, but I refer particularly to those which have to do with the examination and the listing of firemen and engineers.

There are three grades of examinations: firemen, stationary engineers and chief engineers. Applicants for such positions are required to pass an examination before entering the service, but a man who successfully passes the engineers' examination can hold a position as fireman and similarly one who has passed as chief engineer can hold practically any position in the engineering department of the service.

Applicants for examination as fireman are required to be American citizens, residents of the State, 21 years of age, and physically and morally capable of taking charge of a boiler room. Furthermore, they are required to give at least three good references and to show where and for what time they have been employed during the previous five years.

The examination, which is quite strict and practical, may be written or oral, or both, and it usually lasts from three to five hours. A minimum percentage of 70 is required for passing and as experience counts 50 per cent. and technical knowledge, etc., counts 50 per cent., it is plain that a man with book knowledge and no experience cannot pass, and *vice versa*. Any serious-minded man with a year's previous experience and good habits ought to make a fair showing, however.

The engineers' examination is similar to the firemen's, but it is much more difficult.

When I took the test, which was nearly all written, I scribbled from 9 a.m. to 4 p.m., answering questions on boilers and pumps, heating and ventilating, refrigeration, electricity, steam engines, indicator practice, practical, everyday problems and mathematical computations. I got an average of 92 per cent. and my name was second out of 43 on the eligible list. This examination, although somewhat shorter, was about on a par with those which I took for licenses in two different cities.

An engineer having passed successfully is eligible for appointment in any of the State charitable institutions. The Kankakee State hospital, where I am employed as stationary engineer, is the second largest in the United States; it has a 2000 boiler horsepower, 500-kilowatt electric plant, waterworks, a refrigerating and ice plant, etc., and engineers leaving it with a year's experience and a good recommendation from the chief engineer or the superintendent have no trouble getting good jobs anywhere.

The chief engineers' examination is quite severe, owing to the varied requirements. Applicants must be 25 years of age, preferably with a previous experience as chief and at least five years as engineer and a 10-year total mechanical experience.

The examination, usually written, takes a whole day and the questions pertain to the larger problems of design, installation, operation and maintenance of modern power-plant apparatus as well as finer details. This was the hardest examination I ever took, but I passed with an average of 86 per cent. and am now eligible for appointment as chief in any institution in the State which is controlled by civil-service laws.

All chances for fraud in these tests are eliminated as far as possible; when the applicant enters the room all books, reference papers, etc., are taken from him and he then draws a number which he seals with his name in an envelop that is sent to the secretary of the civil-service commission at the State capitol. His papers are then signed by that number, so that the board of engineers who grade them have no idea of the writer's identity.

The examinations are without cost. The applicant must take an oath before a notary and must get a health certificate from a physician; both are free at the institutions where tests are held, but would cost about 75 cents outside.

Upon discharge from the service the employee's name is taken from the eligible list.

If we are to have State license laws, let them be similar to the civil-service laws and their success, in my opinion, is assured.

ERNEST B. LLOYD.

Kankakee, Ill.

A License Does Not Make an Engineer

A license does not make an engineer. For instance, a simple throttling engine was thrown out and a large Corliss engine installed in its place. The engineer had a license, but he could not manage the new engine, and his job fell into the hands of an old chief engineer and things got worse. He burned out a bearing and excused himself by saying that he had been used to running plants where they had someone to look out for the engine. I think this is true of many chief engineers—they have someone to hold them up, and when they depend on their own resources they fall down.

Another engineer, without a license, obtained the job and the engine is running nicely, and the plant is in first-class condition. This man without a license is there with the goods.

I am not against the license law at all. I think it does a lot of good—but there are plenty of men without them who can hold their own with the next one.

C. R. MCGAHEY.

Baltimore, Md.

Kerosene in Blowoff Pipe

In the plant where I am employed it is customary to put about two quarts of kerosene in each boiler before filling with water after washing. Recently while washing out one of the boilers the blowoff became clogged with scale, which was removed by taking off the blowoff-valve bonnet. This was replaced, the oil put in and the boiler filled as usual, when a small stream of oil was found running from the joint between the bonnet and the body of the valve and which continued to run until all of the oil had run out.

This raised two questions which I cannot answer: Why did not the oil rise to the top of the water in the boiler instead of staying in the blowoff pipe? If the oil had not leaked out at the flanges, would it have got hot enough to explode?

A. STAMBAUGH.

Weleetka, Okla.

Some Load!

The accompanying diagrams were taken from an 18x42-in. Corliss engine of well known make. The engine makes 82 revolutions per minute.

I have taken indicator diagrams from upward of 3700 cylinders in the last 14 years and this is the heaviest load that I have yet found.

DIAGRAMS SHOWING HEAVY LOAD ON ENGINE

I would like to hear from other readers as to the amount of loss due to the lack of expansion. In other words, what is the difference in steam consumption between this engine and one which cuts off so as to obtain the full benefit of expansion?

H. I. FRYANT.

Jackson, Miss.

Measuring Furnace Temperatures

The following method of finding the temperature of a furnace, although approximate, is accurate enough for all practical purposes.

By means of the accompanying formulas and tables the temperature can be read off at a glance without having recourse to elaborate calculations.

In the *Journal of the Worcester Polytechnic Institute* (November, 1906), C. F. Howe and C. B. Harrington have an article on tests which they performed on firebrick to determine its specific heat. From the data given in that article, after reducing to practical units, I have obtained the following formula for the specific heat of firebrick:

$$S = 0.000034\ T + 0.213 \qquad (1)$$

where T is the temperature to which the firebrick is subjected and S is its specific heat at that temperature.

In Table 1 is given the specific heat of firebrick at different temperatures deduced from formula (1).

TABLE 1

Temperature T, degrees F.	Specific Heat S.
200	0.220
400	0.226
600	0.233
800	0.240
1000	0.247
1200	0.254
1400	0.261
1600	0.267
1800	0.274
2000	0.281
2200	0.288
2400	0.295
2600	0.302

Since a firebrick can be easily obtained around any furnace, the temperature of the furnace can be found from the following formula:

$$T_3 = \frac{W(T_2 - T_1) + T_2 GS}{GS} \qquad (2)$$

T_3 = Temperature of the furnace;
W = Weight of water in which firebrick is quenched;
T_2 = Final temperature of water after brick has been quenched;
T_1 = Original temperature of water before immersion of firebrick;
G = Weight of firebrick used;
S = Specific heat of firebrick.

If from Table 1 is taken the average specific heat of firebrick from 200 to 2000 degrees (the range of temperature through which the firebrick would probably be heated) it is found that this amounts to about 0.25.

Take a piece of firebrick 4½x2½x4 inches in size (the standard size of a firebrick is 2½x4½x9 inches), which will weigh about 3 pounds. Now take 17 pounds of water, about 2 gallons, and formula (2) may be reduced to the following form:

$$T_3 = 23.7\ T_2 - 22.6\ T_1 \qquad (3)$$

Making $T_1 = 70$, there is had

$$T_3 = 23.7\ T_2 - 1586 \qquad (4)$$

In Table 2 is given values of T_3, corresponding to the temperatures T_2 deduced from formula (4).

So that all that is necessary to obtain the temperature of a furnace is to take a piece of firebrick 4x4½x2½, which will weigh about 3 pounds. Place this in the furnace and let it heat up to the temperature of the surrounding gases. Meanwhile, prepare 17 pounds of water at a temperature of 70 degrees. Remove the piece of firebrick from the furnace and quickly transfer it to the water. Keep on stirring the water until the thermometer no longer shows any increase. Then, by noting this highest temperature, which is designated as T_2, the temperature of the furnace, which is designated as T_3, may be found in Table 2.

TABLE 2

Final temperature of water T_2, degrees F	Temperature of furnace T_3, degrees F
80	510
90	547
100	784
110	1021
120	1258
130	1495
140	1732
150	1969
160	2206
170	2443
180	2680
190	2917
200	3154

SAMUEL B. KANOWITZ.

Baltimore, Md.

This Man Hates Us!

I own a threshing rig and steam plow. Would like to send you some views this winter. I am running the engine in the mill here and I also have charge of the city electric-light plant.

Reading POWER did it!

P. C. FORGARD.

Lake Preston, S. D.

Oil in Boilers

About two weeks ago the girth seams of one of the boilers which I am operating began to leak. After examining the boiler I found that there was oil in it.

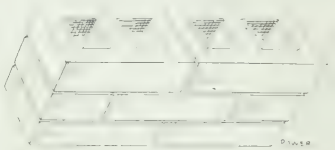
I took out the back manhole plate and, after filling the boiler above the flues, I put in 40 lb. of sal soda and ½ gal. of coal oil. I kept a slow fire under the boiler and let the mixture boil 18 hours. After opening up the boiler again and washing it out, I found it perfectly clean, there being no traces of oil in it whatever, and when the boiler maker had calked the seams it was in fine shape.

A. S. DILLON.

Kansas City, Mo.

Brick for Boiler Walls

The accompanying illustration shows a brick with a hollow space in the center, which I would suggest for use in building partition and outside boiler walls.



BRICK FOR BOILER WALLS

I would like to have the opinion of POWER readers on whether boiler settings of hollow brick have ever been built, and whether they have been satisfactory.

LEWIS L. SCHEIDERER.

Marysville, Ohio.

Glass Gages Break on Separators

There are 80 steam separators in this city and there is not one that can hold a glass more than two weeks. Why should there be any more trouble with glasses on separators than elsewhere? I wonder if engineers generally find this to be the case.

J. W. DICKSON.

Memphis, Tenn.

Water Softeners

I would like a little information from those who have had experience with water softeners or purifiers and filters for preventing the scale-forming matter from getting into the boiler and with what results; also, some data as to cost per thousand gallons purified. I have been told that water so treated will leave a scale so hard that a mechanical cleaner will not cut it.

I am not in favor of boiler compound to get rid of scale because this is trying to cure the effect instead of removing the cause.

J. C. HAWKINS.

Hyattsville, Md.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Large Saving in New York City's Coal Bill

In view of the publication, in a recent issue of POWER, of statements on the authority of the Bureau of Mines that "by purchasing coal under definite specifications bidders are put on a strictly competitive basis, the purchaser is insured against poor quality, rejectable coal may be accepted at reduced prices, and there is a check on the practicable results obtained," the experience of the department of water supply, gas and electricity of New York City during the past year is of interest.

This department has the largest fuel bill of any of the departments of the city government. Practically all of the water supply of the boroughs of Queens, Brooklyn and Richmond is obtained from driven wells, and the pumping of this water and the maintenance of the pressure throughout the other boroughs necessitate the operation by the department of fifty-two pumping stations. The enormous amount of coal used in these stations is seen from the fact that when Commissioner Henry S. Thompson assumed office on Jan. 1, 1910, the annual coal bill had, for many years, approximated $600,000. This was one of the first matters which Commissioner Thompson took up when he reorganized the department, and the result of the working of the new methods which he put into use was a reduction in coal cost in 1910 over 1909 of $122,514. This is a decrease of nearly 25 per cent. in one year and the commissioner expects the bills to show a further reduction for 1911. Together with this decrease in the coal bill of the department, 2.5 per cent. more water was pumped by the various stations in 1910 than in 1909.

While the cost per ton of the various kinds of coal used was not decreased to such a large degree, the quantity of each kind of coal was substantially rearranged. The price of broken coal, of which 64,001 tons were purchased in 1909, was reduced from $4.97 to $4.90 a ton, but only 7742 tons were purchased in 1910; this made a difference of $23,235 in the total bill of $317,876.

The greatest reduction in the price per ton was obtained in pea coal, which was bought at $4.04 per ton in 1909 and for $3.89 in 1910. At the same time, several more hundred tons were purchased in 1910 than in 1909, the total being 25,948 tons in 1909 and 29,202 tons in 1910.

No reduction in the price of buckwheat coal was obtained, it being bought at $3.04 per ton for both years, but many more tons were purchased in 1910 than in 1909, the figures being 80,064 as against 16,346 tons. This made an increase on this item of from $49,732 to $243,394.

The offset to this and the bringing about of the enormous decrease was obtained by the rearrangement of the purchasing of bituminous coal in the same manner as that of broken coal. A reduction per ton was obtained here also of from $3.80 to $3.73 and the amount purchased was reduced from 37,179 tons to 29,777 tons.

Commissioner Thompson called to his assistance in this work several coal experts, and the specifications which he adopted have since been standardized by the board of estimate and apportionment and are now used in the purchase of coal for all of the other city departments.

E. F. HARVEY.

New York City.

A Commercial Water Power Problem

I read with much interest the article by Prof. W. D. Ennis under this heading in the November 14 issue, and while his figures might be correct for the condition under discussion, I do not think that they should be taken for any other condition at the same rate per horsepower. Taking his figure of $25,000 as the value for a 60.3-horsepower water supply, there is a value of $41.45 per horsepower. In Kent's "Mechanical Engineers' Handbook" a similar calculation is given where the computed value of a 10,000-horsepower water power was worth $445,000, or $44.50 per horsepower. This is a close agreement.

I do not think it safe to assume a water-power right to be worth $40 to $45 per horsepower. In my opinion, the value depends entirely on local conditions. Where coal or other fuel is cheap it is worth less than where it is expensive. When exhaust steam is used the power is not as valuable as where it cannot be used and the units are too small to run economically with condensers. Where a large power plant is required the rate per horsepower should not be as high, since turbines can be run very cheaply compared with condensing or noncondensing engines. To my mind, the value of water power is no greater than a sum of money which, when placed at the legal rate of interest, would produce an income equivalent to the actual cost of getting the power elsewhere or producing it with the most economical machinery. In other words, if the power required is enough to justify a high-efficiency turbo-electric unit producing a horsepower for an hour on 2½ pounds of coal, the value should not be based on the cost of producing the same with engines using 3 to 5 pounds of coal just because they happen to be on the ground. Suppose at a later date a power station should be erected in the vicinity which would furnish power equivalent to the cost based on 3 pounds of coal. It will be seen how much money would be lost by buying the water power on a 5-pound rate. If the power were leased on the 5-pound rate, it would certainly have to be dropped under the foregoing condition.

A small user of power could afford to pay much more than a large user. In small plants the cost of a horsepower-year is very high. The labor costs are nearly as much as in a larger plant and in many cases the plant is too small to justify any kind of fuel-saving devices. In fact, most small plants do not have a first-class engineer in charge; usually it is any common laborer who will keep up steam and have the plant in good enough shape to run. They may only get 5 pounds of water evaporated per pound of coal and the engine may consume 50 pounds of steam per horsepower-hour and yet it would never be suspected. To such plants a water power based on 5 pounds of coal per horsepower-hour would be a great saving. To a high-grade plant it would be a big loss.

Another important factor to be remembered is the variability of water flow. In the summer months the flow is so low that many plants are forced to shut down or maintain an auxiliary steam plant. The winter flow is much more, and is often greater than the wheel capacity. In this case the power is worth more than the minimum but less than the full wheel capacity. In this case allowance must be made for the cost of maintaining the auxiliary plant or the necessary expense entailed in the annual summer shutdown because of lack of

water. It would be out of place to try to outline a plan for calculating the value under these conditions as it would vary greatly and be governed entirely by local conditions.

As to the value of water for condensing, Professor Ennis attempts to make the water more valuable as a power producer for this purpose than when it is used in a wheel. I disagree with him on this point. I claim that the water is worth no more for condensing than the cost of pumping from the tailrace to the condenser. The efficiency of a waterwheel will seldom go above 75 per cent. and the efficiency of the best of pumps is about 70 to 80 per cent. Since the power owners cannot claim the water after it has gone below the dam, it would be impossible to prevent the pumping back. Of course, the cheapest way would be to buy an extra amount of water if the power house is up above the dam, but I contend that this water should not be charged higher for on account of the saving effected by improved machinery, but should be sold at the regular power rate. As a rule, power houses are situated as low below the dam as is consistent with local conditions, and in many cases the condensing water can be pumped as cheaply as the water power is worth.

The estimation of the value of undeveloped water power is a matter requiring a thoroughly competent engineer, or better, a board of engineers. It is easily seen that a comparatively small water power is worth a large sum of money, and anyone buying or selling such a source of power would save considerable money by getting advice from several competent engineers experienced in such work.

JAMES E. STEELY.

Covington, Va.

Prof. W. D. Ennis, in his article on the above in POWER for Nov. 14, gives a method for computing the discharge of water through a large opening under a low head that is unnecessary and misleading as it pretends to give a degree of accuracy that is not warranted in the case. In the first place, it is not apparent why he should have computed the results he gives at all, as the diverging mouthpiece on the opening makes the calculations of no value. If, however, it is desired to estimate the flow through such an orifice as his calculations are made for, it is unnecessary to do so in such a round-about manner. Furthermore, an exact method for such a case is not warranted.

In this instance there was an opening 6 ft. wide and 6 in. high, with a head of water on its upper edge of 2.5 ft. Since the head varied from 2.5 to 3 ft., he computed the velocities at different depths, and after plotting a curve obtained the mean velocity which, when multiplied by the area, would give the flow. This is not necessary, as any good textbook on hydraulics would give an exact formula as follows:

$$q = c\frac{2}{3}\sqrt{2g}\,b\,(h_2^{\frac{3}{2}} - h_1^{\frac{3}{2}})$$

where

q = Cubic feet per second;
c = Coefficient of discharge;
b = Width in feet;
h_1 = Depth of upper edge in feet;
h_2 = Depth of lower edge in feet.

This exact formula is to be used only when there is a very low head in proportion to the height of the opening; for if,

d = Height of opening $= h_2 - h_1$;
h = Mean depth in feet.

It can be written

$$h_2 = h + \frac{d}{2} \qquad h_1 = h - \frac{d}{2}$$

and putting these values in the above formula there is a rapidly converging series as follows:

$$q = cbd\sqrt{2gh}\left[1 + \frac{1}{96}\left(\frac{d}{h}\right)^2 - \frac{1}{2048}\left(\frac{d}{h}\right)^4 - \cdots\right]$$

It is apparent that if the value of h is two or three times d, all terms involving $d \div h$ can be neglected; then is had

$$q = cbd\sqrt{2gh}, \text{ or } v = \sqrt{2gh}$$

This latter formula is the one usually used for, except for very large values, of d divided by h, it is as accurate as the reliability of the coefficient c warrants.

In the present case the exact formula gives

$$q = c\frac{2}{3}\sqrt{2g}\ 6\ (3^{\frac{3}{2}} - 2.5^{\frac{3}{2}}) =$$

$$c \times 39.9 \text{ cu.ft. per sec.}$$

The simpler formula gives

$$q = c\,3\sqrt{2g} \times 2.75 =$$

$$c \times 39.916 \text{ cu.ft. per sec.}$$

The slight difference between the two is thus shown. In the case of a standard orifice with sharp beveled steel edges the coefficient c would not be reliable in the third figure perhaps, and in such a case as this one could not select a coefficient which could be depended upon in the second figure. The author chose a value of 0.60, and, as that is not exact, all that can be said is that the flow will be about 24 cu.ft. per second. To attempt such refinements where the circumstances do not warrant it and to give an air of great accuracy where the reality is absent is as bad as the "German method" of guessing at the load on a bridge and calculating the stresses to half a pound.

The article further states that the true ideal velocity is greater than $\sqrt{2gh}$, where h = mean depth. The reverse is shown to be true by the values of discharge computed above and it is also shown by an inspection of the equation in the expanded form.

R. L. DAUGHERTY.

Ithaca, N. Y.

Length of Belt

Referring to the answer given to the question of R. F. H. as to the length of a belt, as printed in the Nov. 28 issue, not many of us are sufficiently familiar with the tables of geometrical functions to work the formula readily. I offer one for readers of POWER that I have used many years. It is more simple and therefore more easily worked out. It is not absolutely correct, but the error is inconsiderable.

The formula is based on the assumption that the line of the belt, in relation to a line drawn through the centers of the two pulleys, may be taken as the hypotenuse of a right-angled triangle whose height is the difference between the radii of the two pulleys and its base the distance between the two centers. Twice the length of the hypotenuse added to half the circumference of the two pulleys will give the length of the belt very closely.

Let

R = Radius of the large pulley;
r = Radius of the small pulley;
D = Distance between centers;
L = Length of the belt.

Then

$$\sqrt{(R-r)^2 + 2D^2} + (R+r) \times 3.1416 = L$$

Taking the conditions of R. F. H.'s problem, L would equal 92.858 feet.

Working out the problem by the previous formula as a check on mine, the result is 92.9019 ft., a difference of 0.0439 ft. or 0.5268 in. in 92+ feet.

WILLIAM HIRST.

Trenton, N. J.

Manufacture of Switchboard Slate

In the November 21 issue, J. J. O'Brien describes a device for sawing slate. The design of this tool and the method of using it seem to be based on the idea that slate is machined similar to other stone. Such is not the case, as I am aware from having been employed for over three years in a slate factory where all manner of slate products were manufactured, including switchboards of all sizes.

All dimensional cutting is done with low-speed circular saws with swaged teeth, and curves and circular cuts are made with an ordinary woodworking bandsaw run at low speed. The speed of slate saws, as I have seen them used, is about 100 feet per minute, and the feed rate about 3 to 6 inches per minute ordinarily, although practice may vary in different localities and with different

dinary work is from 18 to 24 inches in diameter and about $\frac{5}{16}$ inch thick. For light work the saw is smaller and thinner. Any saw that will cut wood will cut slate, but it must not be hurried.

All other operations in machining slate are practically the same as for metal, and no water is used on any saw or tool. If the slate is of good quality and free from flint, mineral veins and spots, a tool will do a lot of work before resharpening is necessary. The dark, natural finish that we are familiar with on slate is produced by first rubbing the piece perfectly smooth with fine emery cloth and then applying a mixture of boiled linseed oil and paint drier. The excess oil is then absorbed with sawdust and the slate is polished by being rubbed with clean waste.

H. L. STRONG.

Portland, Me.

Value of CO_2 Recorder

Much has been said recently in POWER of the importance of CO_2 recorders. Most operating engineers are, in my opinion, somewhat skeptical of such apparatus; furthermore, I believe that many of them take a similar attitude toward all recording instruments.

It appears to me that several of the recent contributors have been discussing the subject from a theoretical aspect rather than from an educational or practical one. I suggest that it be so discussed that whatever is said may be of material value.

Most engineers who do not attach much importance to flue-gas analysis and CO_2 recorders, take such an attitude simply because they are not sufficiently interested in the subject, and because they do not consider boiler-room performance of paramount importance in the everyday operation of the power plant.

Frequently men are opposed to the CO_2 recorder because they have the wrong impression of what it really is designed to accomplish.

I made the following analyses about 18 months ago in a plant burning Island Creek coal under return-tubular boilers, with straight grates fired by hand:

The heat value is 14,709 B.t.u. per pound, as reported by the West Virginia Geological Survey.

In a contributed article on this subject about a year ago I drew the following conclusions:

1. The draft must be sufficient to cause the coal to burn with a bright flame, if good combustion is sought; however, an excessive draft is objectionable in a greater degree than a somewhat insufficient draft, as in the majority of plants a too low evaporation per pound of coal is caused by excess air rather than by carbon monoxide.

2. Smoke cannot be entirely eliminated with a straight furnace (set in accordance with standard specifications) no matter how efficient the fireman may be.

3. The absence of smoke is not an indication of ideal conditions, as they are most frequently secured by the admission of an excess of air, and at the expense of the coal pile.

4. A good flue-gas analysis is preferable to a smokeless stack. The condition to be sought is to get the CO_2 as high as conditions will permit without getting more than a trace of CO.

5. Mechanical stokers cannot make a saving in fuel in comparison with hand firing, unless close attention be given to the prevention of holes or bare spots in the fire; also, most mechanical stokers secure smokeless combustion with volatile coals by the admission of an extreme excess of air.

When I sent this contribution for publication I expected to stir up a valuable discussion upon the subject of flue-gas analysis, but to my disappointment there never appeared a single dissenting line.

Referring to conclusion No. 4, generally speaking, it is advisable to have such conditions as to get the highest possible percentage of CO_2 with only a trace of CO. However, as there are constituents of the products of combustion which are far more valuable from the standpoint of heat value, it is of greater importance to find out by actual working conditions at which particular percentage of CO_2 the highest evaporation per pound of coal can be secured.

Let several evaporative tests be run, the first being run while using the evenly spread fire, aiming to get the highest possible percentage of CO_2.

Let the second be run using the coking method of firing, the main object being to prevent smoke, while using approved methods of cleaning the fires and aiming at all times to prevent an unnecessary excess while cleaning fires, all other conditions being the same.

Let the third test be run using about 0.25 in. of draft over the fire, using the ribbon method of firing and maintaining the fire bed only thick enough to cover the grates, with just a little excess of air over the fire, all other conditions being the same as in the other two tests.

To me there is no question whatsoever but that the last test would make by far the best showing in evaporation, if they were all three equally fair and correct; furthermore, there is no doubt but that the CO_2 would be somewhat lower than in either of the other two tests. Of course, it is understood that the present discussion refers to a highly volatile coal.

Eighteen months ago I thought that the CO_2 should be just as high as possible, say 14 to 15 per cent., but I am convinced that while such a percentage of CO_2 would be advisable in burning a coal low in volatile matter, it would be extremely detrimental to economy in burning a coal high in volatile matter.

In conclusion, I would offer the following:

1. A high percentage of CO_2 is not necessarily an indication of the highest possible economy when firing volatile coals.

2. The percentage of CO_2 should not be as high for highly volatile coals as for those of a semibituminous nature, such as New River and Pocahontas.

3. That under usual conditions a semibituminous coal (Pocahontas) will evaporate much more water per pound of coal than a highly volatile or bituminous coal, both having an equal heat value.

4. That carbon monoxide is not of any great importance, insofar as economy is concerned in everyday practice.

5. The combustion of the hydrocarbons is of greater importance than the prevention of CO if highest economy is desired.

6. Slack or small-size coals give a much higher evaporation per pound of coal in everyday practice than run-of-mine or lump coals.

7. A combination of the alternate and spot methods of firing is most economical and practicable with hand firing.

8. The maximum economy in fuel is more easily maintained with mechanical stokers than with hand firing.

9. All recording instruments are extremely valuable and necessary if economy is to be secured in everyday operation.

WALDO WEAVER.

Tippecanoe City, Ohio.

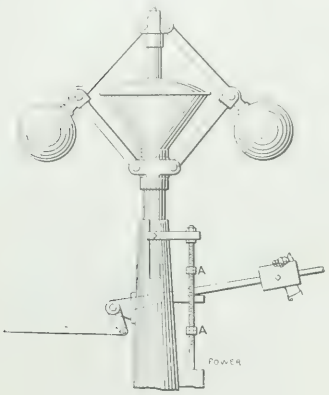
To Stop a Runaway Corliss Engine

After reading the account of the Farmington, Utah, flywheel explosion in the Nov. 14 issue, one might feel inclined to criticize the engineer in charge of the plant. But if one will stop to consider, he will see how easy it is for a man up a tree to criticize a man in a field running a foot race with a bull, and if he should get in first show him where he failed to show class. Also, there is a vast difference between a man sitting at a desk reading and one standing in front of an 18-ft. flywheel running at 200 r.p.m. when its normal speed should be 50.

So, instead, I will say that it is not necessary to close the throttle of a Corliss engine to bring it to a standstill. With a few exceptions Corliss engines are equipped with the ordinary fly-ball type of governor, and if the pulleys or belt do not slip, the weights are thrown to their highest position when the engine starts to race, thereby cutting off the steam. Also, if the governor belt breaks, the governor will drop to its low-

est position; if the nuts *A* in the accompanying figure are in their proper position, the safety cams will come under the roller, thereby preventing the valves from hooking up.

So, if any beginner is caught like the



To Stop Engine Pull Weight Arm Down to Lowest Position

man at Farmington, he need not risk his life in front of the runaway flywheel but may just reach over from the back side of the engine and pull down the governor arm and hold it there until the speed gets back to normal.

A. W. Griswold.

Adams, Mass.

License Laws

Regarding the engineers' license laws, I do not think they are what they should be, because too much of the examination is given over to finding out how much the applicant knows about machinery in general and not enough to his knowledge as to safety.

How many examiners ever ask an applicant to calculate the safe speed of a given flywheel? And yet nearly every week Power publishes an account of a flywheel explosion or engine wreck.

How many engineers are ever examined as to their knowledge of different kinds of governors, their safe operation and faults? Yet the operation of the governor or its failure is often the cause of a wrecked engine.

If the valves on the engine are not properly set, it does not make it unsafe to operate, yet in one examination for a second-class license I was required to set the valves on five separate engines to run in both directions, but not one question was asked about flywheels or governors.

The examinations on boilers and piping should be more strict.

Some of the writers in these columns say that the State and municipal laws should be superseded by a Federal law. This, if properly done, would be the ideal way of deciding the matter, as a license good for a certain class plant in one location would be good anywhere in the United States for the same class of plant. While a Federal law in this respect would be desirable, it would be impossible to get it as it would be an infringment on States' rights and would have to be voted on by the people of the several States and also acted on by Congress.

The license laws at the present time base the classification of licenses on the horsepower of the plant regardless of the pressure carried. I believe this is partly wrong, because a plant of 100 horsepower is just as dangerous and as liable to explosion as one of 500 horsepower, although a higher grade of license is required for the latter plant. The pressure carried as well as the size of the boilers in the plant, together with their number and age, should determine the classification. As the boilers become older the higher-class engineer should be required because the boilers are not as safe and require closer and more expert attention; this is the reverse of what is the usual practice.

If the engineer desires to have a license or certificate of merit or ability to show his competency to handle a given class of plants, let him do so in some such manner as outlined by the Institute of Operating Engineers, which is now being started, and not by compulsory laws as at present.

Several engineers have suggested the civil-service examination for licenses, but if the lists of civil-service questions were asked in an examination for a license to operate a plant, the engineers would set up a great cry of protest.

J. C. Hawkins.

Hyattsville, Md.

Drain Grating for Cement Floors

A good drain grating for cement floors can be made out of old furnace grates that have outlived their usefulness. The wornout furnace grates should be broken into pieces of the desired length, and then embedded in the concrete at the time the floor is being put down.

H. M. Nichols.

Kenyon, R. I.

Substitute Trap Bucket

In the issue of November 14, P. J. McEnaney's letter describing the temporary substitution of a can for the bucket in a steam trap made no mention of weighting the can to insure satisfac tory operation.

If the can was too light and the pressure high, the valve would be held tightly against its seat, and the combined weight of the bucket and the water would be insufficient to pull it away and allow the trap to discharge. In several instances I have caused traps whose maximum pressure range is 40 pounds to operate under a higher pressure without reducing the size of the discharge orifice, which is necessary with an increase of pressure, simply by adding weight to the bucket. Of course, there is a limit to the amount of weight added, and I have found it impractical to add much more than would give 15 or 20 pounds over the maximum pressure for which the trap is intended.

W. Simpson.

New York City.

Crankpin Oiler

Answering Fred L. Wagner's letter in Power for Nov. 28, I fail to see why my arrangement described in the Oct. 3 issue would not deliver almost as much oil to the crankpin at low speed as it would at high speed, as it does not depend on centrifugal force to carry the oil to the crankpin; it is simply assisted by this force, for every time the crank is down, the oil flows to the pin by gravity.

If Mr. Wagner will look at my sketch he will see a parting in the upright pipe to show that the oil cup could be placed at any height above the crank.

If it was desired to use grease, a compression grease cup could be used instead of a sight-feed oil cup; but in such a case also there should be the union and the support, as it would be more troublesome to screw the cap on a compression cup that was revolving, or to tell how much the cap had been turned to force the grease to the pin, than in the case of a stationary cup.

The cup should have a support; otherwise it is likely to be knocked out of true and wabble.

Daniel Ashworth.

Wappingers Falls, N. Y.

A Pumping Problem

Mr. Crockett's pumping problem on page 932 of the Dec. 19 issue is what has sometime been regarded as an anomaly in the practical working of centrifugal pumps. At first sight, it might be inferred that a decreased head would decrease the load on the engine which drives the pump, but the opposite effect is often observed.

This is easily understood when it is considered that the power required is proportional directly to the rate of discharge and head, and inversely to the efficiency. A decrease in the head causes an increase in the rate of discharge and probably a decrease in the efficiency, so that the net result may be an increase in the power, as seems to be the effect in this case.

W. L. Durand.

Brooklyn, N. Y.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Ratio of Expansion

What is meant by ratio of expansion?

M. D.

Divide the length of stroke in inches by the number of inches traveled by the piston before the steam is cut off. The quotient will be the ratio of expansion.

To be accurate the clearance should be added to both quantities before dividing.

Two Eccentrics for Corliss Engines

What is gained by having two eccentrics on the low-pressure side of a compound-condensing engine?

M. J. G.

By using two eccentrics, the steam and the exhaust valves may be set separately, thus permitting a longer range of cutoff for the steam valves and an earlier opening of the exhaust valves and allowing the benefit of the vacuum earlier.

Size of Steam Pipe for Engines

What should be the size of the steam pipe in reference to the size of the cylinder?

J. B.

There is a wide variation in practice regarding the size of steam mains. Each case should take the length and directness of the connections into consideration. A general rule is: Multiply the square root of the horsepower by 0.408.

Point of Cutoff of a Common Slide Valve

Why does not a slide valve cut off in the first half of the stroke?

J. A. C.

The point of cutoff of a simple slide-valve engine is fixed. The speed is controlled by the throttling effect of the governor. For a common slide valve it is not practicable to cut off the steam supply to the cylinder sufficiently early in the stroke as to effect so large a degree of expansion as by a Corliss or other type of valve, because it would require a valve having an excessive amount of outside lap and the exhaust would take place too early in the stroke. Slide valves work to better advantage when the lap is so proportioned as to cut off the steam at from two-thirds to three-quarters of the stroke than at any other point, because of the comparatively long stroke of the valve when more lap is added and the great amount of friction between the valve face and its seat.

Lubricator Piping and Lubrication

Is it good practice to extend the lubricator pipe into the steam pipe? How can I get more lubrication at the valve ends? What is the record for the minimum amount of oil used? Is oil dangerous in a boiler?

D. C. Y.

The lubricator pipe should not extend into the steam space of the main pipe, but should end so that the oil will run down the side of the pipe. Oil grooves cut in the ends of the valves will sometimes aid in getting the oil where it will do its work.

The least quantity of oil used of which there is any record was one drop every two minutes on a 500-hp. compound Corliss engine. Some engines especially in the marine service are run without cylinder lubrication.

It makes a great deal of difference what type of boilers is used as to the danger from oil. With the tubular type, too much care cannot be taken to keep them free; with the water-tube there is much less danger.

Equalizing Clearance

How is the clearance in the cylinder equalized if the piston rod is keyed in the crosshead? How can I get more power out of an engine?

J. K.

The clearance on the cylinder of an engine where the piston rod is keyed in the crosshead can be equalized by adjusting the shims in the connecting-rod boxes. Increasing its speed or its pressure, or putting a condenser upon it, will get more power out of an engine.

Boiler Thimble

What is a boiler thimble?

T. U.

The thimble on a boiler is a ring or bushing placed between the tube and the tube sheets. It is used more in locomotive and marine than in stationary boilers.

Induction Heater

What is an induction heater?

A. L. F.

An induction heater is a dead-end heater having only one opening and connected to the exhaust pipe through a shunt. Part of the steam rises through the opening and is condensed, the water going out at the usual drip and more steam entering the heater to take the place of that which is condensed. Induction heaters are used in places where it is not convenient to place a thoroughfare heater.

Corliss Engine Valves

Is it possible to have all four valves of a Corliss engine closed at one time when the engine is running full speed?

F. A. T.

Yes; if the exhaust valves have lap so that one is closed for compression before the other opens for release. One steam valve will have dropped, the other will not have opened; hence all four valves will be closed.

Priming and Foaming

What is the difference between priming and foaming? What is the remedy for each?

M. K. L.

A boiler primes when water is mechanically carried over with the steam. This is due to forcing, to carrying the water level too high, or to restricted spaces between the tubes, thus making the steam come up in gulps and breaking up the surface of the water. The remedy is to carry a lower water level, take out the central row of tubes in a horizontal return-tubular boiler, keep the feed constant and uniform so as to preserve a constant condition of circulation, and have the rate of operation within that at which the boiler will furnish practically dry steam. When a boiler foams, the contents get frothy. The condition may be brought about by dirty water or by water in which an excess of soda has been used.

Lyons, France, is insisting on a more rigid observance of its smoke laws.

Boiler Explosion in Roswell, N. M.

By J. D. Hudgins

Baty's steam-laundry plant at Roswell, N. M., was the scene of a boiler explosion on the morning of Dec. 21. One man was seriously injured and 15 others experienced a miraculous escape. The writer was in the immediate vicinity of the accident when the explosion occurred and reached the scene about one minute afterward. Upon arrival it was noticed that the tubes exposed by the rupture, shown in the photograph, were at a dark red heat. The boiler was of the return-tubular type 36 in. in diameter and 12 ft. in length, having thirty 3-in. tubes, and was used to heat water for laundry purposes; it was also required to carry 65 lb. steam pressure, gage, for drying and ironing.

View of the Boiler after the Explosion

Upon inquiry it was learned that in closing down the plant at night the practice was to bank the fires and that when the fireman returned the following morning it was not uncommon to find that the fires had burned out, evaporating the water until it did not show in the gage-glass; the noise made by the safety valve, and its disturbance of the people living in the neighborhood is evidence of this fact. The boiler was equipped with an injector for supplying the feed water, and it required a steam pressure of 25 lb. for the 2-ft. lift from a barrel near-by. The first duty of the fireman, as he saw it, was to raise steam and then fill the boiler with water, which he invariably did. Nothing happened from this practice until the morning mentioned above.

Allis-Chalmers Co. in Financial Difficulties

Believing that the Allis-Chalmers Co., of Milwaukee, Wis., could no longer profitably continue its business and meet its obligations, its directors decided, on Dec. 29, to precipitate the company into a receivership by defaulting the interest on its first-mortgage bonds, on Jan. 1.

The stockholders' and the bondholders' committees are working upon a plan of readjustment and upon going to press it is learned that the receivership will be held in abeyance, temporarily at least.

When the company announced its default on the January interest, it became known that Judge Gary had resigned as chairman of the board.

The company was incorporated in New Jersey in 1901 as a combination of four smaller Western manufactories of machinery. In 1903 and 1906 additional departments were added to the company's plants at Milwaukee, Chicago, Scranton and West Allis, Wis. In 1906 also the Bullock Electrical Works, at Cincinnati, were acquired by stock purchase.

The company has authorized $25,000,000 common stock and $25,000,000 cumulative 7 per cent. preferred stock. There is outstanding about $19,820,000 common and $16,150,000 preferred. The par of both is $100. The preferred stock is convertible into common. Dividends at the rate of 7 per cent. a year were paid on the preferred from July, 1901, to Feb. 1, 1904, inclusive. Since then there has been none and that 7 per cent. a year has been accumulating as an obligation. No dividends have ever been paid on the common stock.

The company's bonded debt consists of $11,148,000 first sinking fund gold 5s, dated July 1, 1906, and due July 1, 1936. Its accounts show that in the fiscal years 1905-06 and 1906-07 there were good-sized deficits. In 1907-08 there was earned on the preferred 3.81 per cent., in 1908-09 0.84 per cent. and in 1909-10 3.07 per cent.

PERSONAL

A. G. Roberts has been appointed chief engineer at the municipal lighting plant of Pasadena, Calif., succeeding W. M. Glass, who recently resigned.

Walter J. Jones, consulting engineer, 30 Church St., New York City, has been appointed engineer to the electrical commission of Montreal, Quebec. He will have immediate supervision over the work of gathering data and laying out a complete municipal underground system for that city.

F. C. Holly, chairman-secretary of the Col. Goethals Branch No. 1, at Yazoo City, Miss., has resigned this position on account of his removal to Memphis, Tenn., where he is superintendent of the Perkins Oil Co. W. G. Richardson has been elected to fill the position made vacant by Mr. Holly.

OBITUARY

Allan Harris Crowell, vice-president of the William A. Harris Steam Engine Co., of Providence, R. I., died at Channing Hospital, in that city, on Dec. 27. He was the only son of E. Francis Cromwell, secretary and treasurer of the company. Death was due to intestinal indigestion, from which he had been suffering since Nov. 1. Mr. Cromwell was about 25 years old and had been associated with his father in business since leaving school. He is survived by a widow and two children.

Edward Sawyer, widely known as a civil engineer and an authority on the construction of water and sewer systems, died at his home at Newton, Mass., on Dec. 27. He was 73 years of age. Mr. Sawyer, in partnership with J. Herbert Shedd, constructed the sewer and water systems in the city of Providence. He also had a large share in the engineering problem of the division of water for power purposes along the Blackstone River, had charge of the construction of the power plant of the Chicopee Mills, was one of the founders of the Sawyer Spindle Co., of Boston, and since his retirement from more active work had served as consulting engineer on the Cochituate water plant, from which the city of Boston receives most of its water supply, and for other large water systems. He was a member of the American Society of Civil Engineers, the Boston Society of Civil Engineers and the Boston Society of Arts.

POWER

Vol. 35 NEW YORK, JANUARY 16, 1912 No. 3

Once there was a man belonging to a certain engineers' organization whom his fellows came to look upon as a sort of mine of information, both general and specific.

Whenever you put a question to him concerning some phase of "power-planting," if he couldn't answer you offhand he would say, "I'll look it up." And sure enough, he would. The next time he saw you he would have a whole bunch of interesting facts and figures to give you.

Whenever the association listened to a lecture or to the reading of a paper, this man always came primed with intelligent questions to ask and, usually, he had a few illuminating remarks to make as well. And let us tell you, friend, the ability to ask intelligent questions usually results from a fairly earnest study of the subject in question.

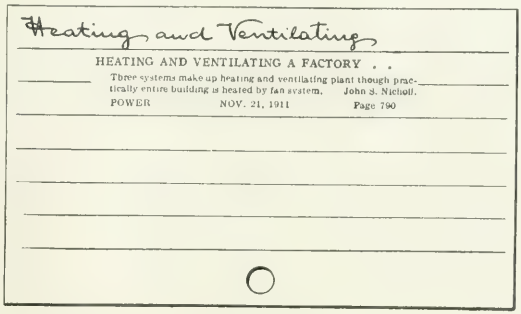
Well, one day, as was inevitable, he was asked how he did it and in reply he said:

"I am a collector, not of stamps, old coins or first editions, understand me, but of facts, figures and fancies concerning the science of power generation and transmission, the which affords me bread and butter.

"Any article I see in a magazine or journal which seems worth preserving for reference after I have read it, I clip out and file away.

"I started in with one small cardboard file or transfer box. I had no index. The box contained a set of stiff paper separator sheets, each with a letter of the alphabet marked on it at the edge. I filed each article under the initial letter of the most suggestive word in the title. It was no time before I had that box filled. Then I filled another and still another. By this time the lack of an adequate index began to be a bit of a hardship and I decided to use a vertical filing cabinet and a card-index and cross-reference system. Then, not only could I index what clippings I actually had in my file but I could also index many articles of which I could not or did not wish to make clippings."

POWER, beginning with this issue, will arrange the "Outline of Topics" page so that the title, the brief synopsis, the author's name, the date of issue and the page number of each article will form a neat paragraph that may be clipped out and pasted onto an index card in the manner shown herewith. All that will then remain to be done is to write the general heading on the first line and place the card in its proper place in the index.


Heating and Ventilating

HEATING AND VENTILATING A FACTORY . .
Three systems make up heating and ventilating plant though practically entire building is heated by fan system. John S. Nicholl.
POWER NOV. 21, 1911 Page 790

We know that this new arrangement will be welcomed by those who now maintain a reference index and we hope that it will encourage others to start the construction of one.

High Vacuum, Reciprocating Engines

By H. Fothergill

An argument for the use of a high vacuum with reciprocating engines, showing how it may be employed to advantage by properly designing the exhaust ports and passages of the low-pressure cylinder. Tests are cited to substantiate this.

Considerable interest is afforded by a paper by K. Heilmann, of Magdeburg, Germany, with reference to the efficiency of reciprocating engines, which was abstracted in the Oct. 31 issue of POWER. In this much attention has been given both theoretically and by practical experiment to the effect of steam superheating and cylinder condensation.

Articles are constantly appearing which deal with the subject both with reference to steam superheating and cylinder condensation, but the question of vacuum as affecting steam consumption and increased horsepower has, however, received only casual attention and considerable error in the conclusions arrived at is likely to be the result unless the matter be thoroughly investigated.

It is held by many engineers that any augmentation in the condenser vacuum above 24 or 25 in. does not result in such an increase in steam economy as would fully justify the extra initial cost of installing a condensing plant suitable for the higher vacuum, and therefore it has become more or less standard practice with reciprocating engines, to design the condensing plant for a vacuum of about 25 inches.

The general acceptance of a low vacuum as being best suited for reciprocating engines has no doubt been arrived at from results previously obtained by steam-consumption trials at varying vacuums. Fig. 1 illustrates a typical example of the effect of vacuum on the steam consumption of compound and triple-expansion engines having cylinders of ordinary design. In both cases the rate of decrease in steam consumption rapidly falls off toward the higher vacuum; in fact, the curve at the higher vacuum approaches closely to the horizontal.

In the triple-expansion engine it will be seen that from 20 to 26 in. the total economy is 1.27 lb., equal to 1.87 per cent. per inch of vacuum over this range; while from 26 to 29 in. the total economy is 0.08 lb., representing 0.23 per cent. of improvement per inch of vacuum, a very slight gain as compared with the economy obtained over the lower range. In the compound engine the gain at the higher vacuums is even less, due, of course, to the lower number of expansions and to the greater cylinder condensation.

From such observations as these it would naturally appear that the production of the higher vacuum in order to realize the slight increase in economy is not justifiable, and engineers were unanimously of the opinion that for reciprocating engines the greatest overall economy in the engine room could be obtained with a vacuum in the neighborhood of 25 inches.

There is no reason, though, why the curves should not continue in a downward direction and a higher economy be obtained provided the low-pressure cylinder be suitably designed to respond to the higher vacuum, and in overlooking this fact engineers have arrived at the false conclusion that the lower vacuum is the most economical.

The true effect of high vacuum on the steam consumption and increased horse-

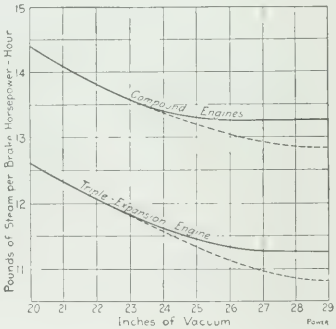


FIG. 1. EFFECT OF VACUUM UPON STEAM CONSUMPTION

power of reciprocating engines has perhaps for the first time been most thoroughly dealt with by D. B. Morison, who has proved beyond doubt that the increase in steam economy due to the higher vacuum fully justifies its use, provided the ports and passages of the low-pressure cylinder are of such proportions as will permit of the unrestricted flow of steam into the condenser.

In considering the ports and passages of an ordinary low-pressure cylinder, the exhaust areas are such as to produce a high velocity of steam when the pressure on the exhaust side of the port is lower than that on the piston side, the velocity, of course, being dependent upon the quantity of steam passing per square inch of port area. Steam turbines may be constructed so that a high exhaust velocity occurs only with exceedingly high vacuums, and, therefore, the difference in pressure between the condenser vacuum and the vacuum in the low-pressure section of the turbine under normal conditions is very slight and the turbine fully responds to the higher vacuum. Hence, reducing the exhaust velocity and minimizing the pressure difference between the condenser and the low-pressure cylinder in reciprocating engines is a problem worthy of careful consideration, as the quantity of heat available for doing useful work in the engines is dependent upon the pressure on the exhaust side of the ports.

Mr. Heilmann found from tests carried out at the works of the manufacturers of the "locomobile" engine at Magdeburg that the efficiency of the engine reached its highest value with about 80 per cent. vacuum. With higher vacuums, the losses were increased, due to the throttling effect between the low-pressure cylinder and the condenser, and yet apparently no attempt was made to avoid this by constructing the ports and passages of the low-pressure cylinder so as to minimize the throttling effect and obtain the full possible benefits resulting from the higher vacuum.

Careful experiments have recently been conducted by R. L. Weighton in order to arrive at a definite conclusion as to the economy derivable from high vacuums, and a series of steam-consumption tests were made with both triple- and quadruple-expansion reciprocating engines at varying vacuums. The first set of tests was recorded from the engines when fitted with low-pressure cylinders of ordinary design. Before taking the second readings the low-pressure cylinder was removed and a new cylinder having specially designed ports and passages of large cross-sectional area was fitted in its place.

The results obtained from the first readings were represented by curves similar to those shown in Fig. 1, while the results obtained from the second readings with the new low-pressure cylinder having enlarged ports showed a uniform increase in steam economy up to the highest vacuum carried in the condenser. In the case of quadruple-expansion engines, the saving in steam between 25 and 28¼ in. vacuum was 5 per cent. and in triple-expansion engines 4 per cent.; the actual results obtained were as follows:

GAIN FROM 25 TO 28¼ IN. VACUUM

	Saving in Steam per B.hp., Per Cent.	Increase in B.hp., Per Cent.
Quadruple-expansion.	5.1	5.9
Triple-expansion	4.2	5.0

The reason for the gain in power being slightly greater than the gain in economy is because the higher vacuums entail a slight increase in steam consumption per revolution. There is therefore no doubt that had the engines from which the results shown in Fig. 1 were obtained, been fitted with low-pressure cylinders having enlarged ports and passages, the steam consumption at the higher vacuums would have been considerably reduced, as indicated by the dotted lines.

The next question to consider is the cost of obtaining this increased economy and how it compares with the actual saving effected. It has been stated that the expense of increasing the cross-sectional area of the ports and passages of the low-pressure cylinder adds to the first cost of the engines, but such is not the case, however, and it has been proved that the dimensions of the ports and passages necessary to permit an economical utilization of vacuums up to even 29 in. are moderate and not at all difficult to attain in practical designing, nor do they add appreciably to either the bulk, weight, friction or first cost of the engines.

A high vacuum is, in general, applicable to all types of reciprocating engines, maximum economy being obtained in large slow-speed engines with the ports of such dimensions as to permit the highest vacuum to produce such a diminution of pressure in the low-pressure cylinder as will make such a vacuum exceedingly advantageous. In small high-speed engines, it is not generally advisable to aim at the utilization of extreme vacuums, as the effect of increasing the ports has also the effect of increasing the clearance space, but even with moderately high vacuums the high thermal efficiency of this type of engine enables excellent economy to be obtained.

The largest field for a high vacuum in connection with reciprocating engines appears to be in the design of triple- and quadruple-expansion marine engines and it is in this direction that the greatest headway has been made; in fact, it is now becoming the recognized practice with British engineers to design engines upon this principle. A typical example of high-vacuum triple-expansion engines as constructed by Messrs. Richardsons, Westgarth & Co., Ltd., Hartlepool, England, is illustrated in Fig. 2, which represents a back view of the engine, showing the condenser and pumps. It will be noted that the exhaust pipe is of large diameter and the space occupied by the condenser is relatively small.

The air-withdrawing capacity of any reciprocating air pump of a given size depends on the difference between the vacuum that can be produced in the pump barrel on its suction stroke and that of the vacuum in the condenser. But if water of condensation enters the pump at a temperature corresponding to the vacuum in the condenser, it would obviously boil as soon as the pump bucket commenced its suction stroke, and the resultant vapor, by filling the barrel, would impair the inflow of air from the condenser. If, on the other hand, the water entering the pump were so cold that it did not boil during any portion of the vacuum-producing stroke of the air pump, then the vacuum produced in the barrel would be much higher than in the condenser and the flow of air into the pump would be a maximum. Therefore, an air pump can be rendered very flexible in air-withdrawing capacity by the temperature, and if there are means for controlling this, then the air-withdrawing capacity of a single pump can be regulated in accordance with the quantity of air to be withdrawn and the vacuum required.

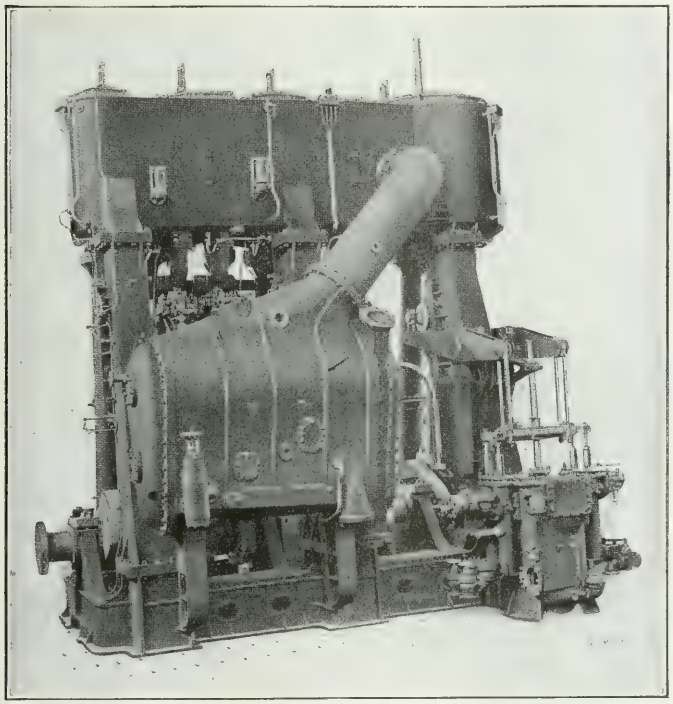


FIG. 2. TRIPLE EXPANSION MARINE ENGINE DESIGNED FOR HIGH VACUUM

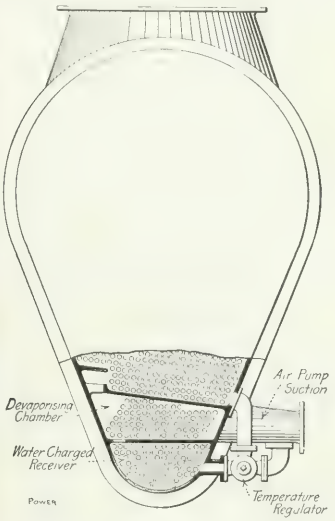


FIG. 3. CONTRAFLOW CONDENSER WITH TEMPERATURE REGULATOR

The condenser illustrated in Fig. 3 contains a receiver divided off at its base which is always completely filled with water of condensation. At a distance above this water receiver is a diaphragm which catches the water of condensation formed in the condensing chamber above it.

There is a pipe connecting the top of the water-collecting diaphragm and the water receiver, and in this pipe there is inserted a two-way cock or valve, one way leading to the air-pump suction pipe and the other to the water receiver. If there is a clear way between the water-

collecting diaphragm and the water receiver, all the water of condensation passes through the receiver and is reduced in temperature before it passes into the air pump. If, on the other hand, there is a clear way between the collecting diaphragm and the pump, all the water of condensation passes at a maximum temperature into the pump. The temperature of the pump, and therefore its air-withdrawing capacity, is under complete control by the partial or the full use of the temperature regulator.

Experience has shown that by the use of this temperature-regulating device for cooling the whole or a portion of the water before passing into the air pump, a low vacuum in the tropics can be raised by from 1½ to 3 in., and often more; at the same time the air-pump discharge water is kept at the highest temperature consistent with the maintenance of the highest available vacuum in the condenser.

It has been advanced by some engineers that any increase in economy on a steamship resulting from a high vacuum is impaired by the loss of heat units due to the reduced temperature of the feed water. Such a statement can apply only to out-of-date steamships. According to modern practice, the feed water in a steamship is heated to pumping limits by the available exhaust steam from the auxiliary engines, which is generally found to be more than sufficient for that purpose. The temperature of the feed water is therefore independent of the temperature at which it passes through the air pump.

It is only natural, however, when a considerable gain is effected in one quarter, to look for a possible loss in another quarter, and one might be inclined to think that the pumping power required for circulating the extra condensing water through the condenser to obtain the higher vacuum would be abnormally high, but by simple calculation it can be shown that the increase in pumping power is so small compared with the increase in the horsepower of the main engines that it is unworthy of consideration.

A Boiler Room Argument

By F. Webster

"Look out for your clothes!" I cautioned banteringly, as Denny stood near the open furnace door while the induced-draft fan tugged at the smoke flue. The door clanged shut, he hooked the hoe into the lattice braces of the nearby roof post and slammed the handle against the foot of it.

"Thim air-blowed, man-operated furnaces make me lose everything but me appetite," he declared, turning his grimy face square at me. "T'row the windsucker outfit into the river. Thin put in a steam blower, an' ther fires can be forced wid half ther labor an' widout cost fer fuel."

"That's going some," I said; "the agent who put in that induced-draft outfit promised to operate it on only 3 per cent. of the steam, or with 85 per cent. of the steam that would be used by a jet blower. If a steam blower will be better than a fan, I am here to be shown."

Denny heaved a heavy sigh at my ignorance, and he turned to the patent weighing chute. After dropping a ton of dirt onto the floor he drew forth a copy of the *Stokers' Journal* from his hip pocket.

"This theoury of blowin' cold air into ther ashpit, or of sucking the smoke out of the breeching is all clinker," he contemptuously remarked, as he turned over the advertising pages of the *Journal*. "Fans take nearer tin per cent. than t'ree per cent. of ther steam, no matter what agents may say. As it takes more draft to burn dirt than it does to burn lump coal, it is roight here that ther agents for all sorts ov air machines get in their wurruk on ther boss; whin they learn that he is thinkin' ov changin' over so as ter use a cheaper fuel, or is hot-foot for makin' a savin', they come whinin' around like coyotes that smell dead horse."

Denny had been a cowboy before he entered the engineering field and his mind frequently wandered to the days of his stunts in the sagebrush. "Takin' fer granted that somethin' must be used ter force a dirt foire, what sort of a hitch should it be?" he continued. "I say that steam-jet blowers beat forced-draft fans.

"Air is four-fifths waste. Ther nitrogen fills up ther space, an' does nothin' fer combustion itself; besoides, it hinders ther oxygen, which is one-fifth of ther air, from gettin' at ther foire and ther burnt gases from gettin' out ov ther stack. A blast ov air widout steam in the ashpit will make clinkers, an' anny foire that clinkers will not get all ther heat out ov ther coal. Tryin' ter be ecconomical ther fireman lets a jet ov exhaust steam from some ov ther ingines into ther ashpit; or, fer convanyance, ther steam may be piped into ther air duct at some distance from ther furnace. In ayther case, he don't get much steam into ther foire at all, but he has ter rowl up his trousers ter keep out ov ther watther that comes onto ther floor. Ther cold air condenses ther exhaust steam an' afther a whoile ther pit overflows like anny ol' irrigation ditch. But jist use hoighly sooper-heated steam direc'ly on ther spot an' ye have a double cinch on anny furnace."

"Steam has to come out of the boiler, and hot talk will not superheat it," I remarked. "Water is not a fuel, and putting superheated steam into the fire may prevent clinkers, but where is the economy of using live steam for blowing?"

"They all talk that way, avan afther they've bin bit," Denny replied knowingly. "This is because they don't know sooper-heated steam in furnace operashun. Ye see," he continued, reading from his paper, "ther sooper-heated steam does ther blowin' an' it also gits into ther foire. There ther steam gits decomposed by ther high heat inter its component gases, hydrogen and oxygen. Ther hydrogen passes on into ther combustion chamber where it moight unite wid ther oxygen of ther air an', burnin', forms watther. Its burnin' gives back ther heat that was absorbed from ther foire to decompose ther sooper-heated steam, an' this returned heat affects ther boiler at ther rear ov ther ordinary hot spot. Thus ther schame extinds ther furnace effect. Ther watther vapor from ther burned hydrogen passes up ther stack wid ther other waste gases. Ther oxygen from ther decomposed steam aids in burnin' ther coal, an' ther gas formed by ther union ov wan atom ov oxygen wid wan atom ov carbon will take up wan more atom ov oxygen in ther hot area where ther hydrogen is burnin' an' thus add greatly to ther furnace heat. The sooper-heated steam jet can be used as a blower ov wan hunderd per cint. efficiency."

"Whew! Perpetual motion in the boiler furnace, and the Patent Office only 500 miles away!" I exclaimed. Similar efficiencies are common in stock prospectuses, especially those originating in Boston and Philadelphia. Taking heat from the burning coal to decompose water, or live steam, and then getting a return of the heat by burning the hydrogen at another location under the boiler, is a scheme that makes one's head dizzy. I suggested that, before he spread his secret broadcast, he condense the steam from the jet blower and weight it; also, that he find out the nature of the gases that went up the stack.

"I'll admit," Denny interjected, "that ther steam-jet blower will use as much or more steam as ther fan, but it can do so widout anny operatin' cost, an' ther whole outfit nade not cost more than a dozen dollars. Wid ther sooper-heated steam jet ther boiler gits heat not only from ther burnin' coal directly but also from ther burnin' hydrogen, as it recombines wid ther oxygen farther back in ther furnace."

The whistle blew and I ducked with this parting shot: "What'll you give me per ton for extra fine water for fuel?"

I went down the street, musing on what would happen if one ever got blowers of 100 per cent. efficiency. Then there came to mind the philosophy of the old farmer who was seen putting a dead snake in each hill of corn for a fertilizer. "Wa'll it's jest this way," he explained when questioned, "snakes make corn, corn makes whisky, an' whisky makes snakes."

Smoke Prevention with Steam Jets

By J. A. Switzer

The introduction of a system of smoke consumers, consisting of automatically controlled steam jets over the fire, not only reduced the smoke about 90 per cent. but also greatly increased the plant efficiency. The coal used was high in volatile matter.

Knoxville Ry. & Light Co.

The boiler equipment of the Knoxville Ry. & Light Co. consists of three 300-hp. Stirling and five 600-hp. Babcock & Wilcox boilers; the latter are superheating and all are hand-fired. A system of forced draft is installed for occasional use, but ordinarily natural draft suffices. There are two chimneys cross connected; that is, the breeching is continuous from one end of the battery to the other. The plant operates condensing and there is the usual complement of boiler pumps, feed-water heaters, etc. All eight boilers have been equipped with the smoke consumers, and Fig. 1 shows one of the larger boilers thus equipped. In Figs. 2 and 3 are shown respectively the average appearance of the stacks before and after installing the consumers.

Ordinarily two of the 600-hp. boilers serve to carry the night load, three the day load and four the peak load; but on holidays and special occasions the entire battery is taxed to furnish the requisite power. Coal is purchased on the B.t.u. basis and is regularly analyzed.

Smoke consumers were put in under a contract making the following guarantees: First, to abate 90 per cent. of the smoke; second, to increase the capacity of the plant 10 per cent. or more; third, to reduce the accumulation of soot on the tubes 50 per cent., and, fourth, to effect an actual saving of 10 per cent. of the fuel. These guarantees were to be determined, first, by means of two evaporative tests, and, second, by a comparison of the coal consumption per kilowatt-hour during the month next succeeding that in which the installation was made with the coal consumption of any month during the year 1910. The contract further specified that should the equipment fail to meet the guarantee as judged by either of these tests, or should it not prove entirely acceptable to the company, it was to be removed and all charges were to be cancelled.

The smoke-consuming apparatus consists of a steam line terminating in jets placed just inside the special fire doors which are fitted with dashpots connected by a lever system to automatically controlled valves. The arrangement is such that when a door is opened for stoking the steam is automatically turned on and discharged into the combustion chamber. When the door is closed after firing, the steam continues to blow, and dampers on the door are held open for a period of three or four minutes; then the motion of the dashpot slowly closes the dampers and throttles the steam.

The action in abating smoke is as follows: When fresh coal is fired upon the hot fuel bed, the combustible volatile matter begins instantly to distill in great quantity. For the complete combustion of this gas an increased supply of air is immediately required. The steam jets create the draft and the open dampers furnish the avenue for the admission of this supply of air. But in addition to fulfilling this function, the jets by a swirling action serve to bring about a complete mixing of the air and combustible gas, thus insuring practically complete combustion before the burning gases can come into contact with the heating surfaces.

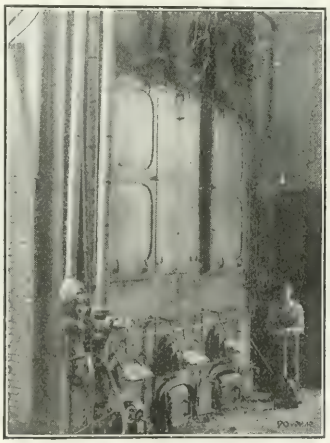


Fig. 1. Showing Smoke Consumers Applied to Boiler Front

Evaporative Tests

These tests were each of 11 hours' duration and were conducted by the writer with the assistance of engineering students of the University of Tennessee, the station engineer participating.

Methods Employed

Coal is distributed to the boilers by a bucket conveyor and was weighed in this bucket on a special-test platform scale. The weights were calibrated on the ground and were found to be correct to within less than one-tenth of 1 per cent. The alternate method of running the test was employed.

The feed water was measured by means of a 3-in. Venturi meter, and observations were made every minute throughout the test. The meter was calibrated with great care and the probable error of feed-water measurement did not exceed 1 per cent. At the end of each test the water in each of the gage glasses was brought back to the string marking its level at the beginning.

Coal was sampled at the time of weighing, and determinations of the heat value were made with a Parr calorimeter.

Just prior to installing the steam-jet apparatus the company had equipped its boilers with soot blowers. In order to eliminate any influence which the use of these blowers might have upon the performance of the plant during the tests, it was agreed that the blowers should not be used for 36 hours preceding each test.

The indicating wattmeters were read every minute throughout both tests. The readings were plotted upon cross-section paper, and the curves integrated with a planimeter. In order to guard against personal error, instantaneous readings were made. At the beginning and end of each test the watt-hour meters were also read; but since these instruments cannot be read closer than to the nearest 1000 kw.-hours, dependence could not be put upon them. It is interesting to note, however, that in both tests the agreement between the two sets of instruments was closer than the latter could be read, being in both tests within about 800 kw.-hours; and in both tests the variance was in the same direction.

Smoke Observations

Smoke observations were carried on by comparison with the Ringelmann chart, and were made every minute during the tests. From these observations the charts were plotted as shown in Fig. 4. However, a comparison of the two charts utterly fails to indicate the degree of smoke abatement accomplished. The Ringelmann method of observation takes account only of the color of the smoke and not at all of its volume. While it is true that since the installation was made the smoke occasionally reached a blackness of No. 5 for short intervals of time, its volume during these intervals is as nothing compared to that which was formerly habitual with the smoke. On

the day of the first test, smoke of No. 5 blackness issued forth 72 per cent. of the time; No. 4, 23 per cent.; No. 3, 3 per cent., and No. 2, 2 per cent. Not once during the 11 hours of the first test did the smoke from either stack drop below No. 2. During 95 per cent. of the time prior to the installation of the smoke consumers a volume of smoke was generated which now is not equalled for 2 per cent. of the time; and, while the exact percentage of abatement accomplished is purely a matter of individual judgment, it is certain that 90 per cent. of the smoke has been stopped.

The Evaporative Tests

As far as possible, the operating characteristics of the plant were maintained alike for the two tests, except for one particular. It had been customary to carry the day load on three of the 600-hp. boilers, and at about 3 p.m. to cut in a fourth to meet the approaching peak load. The increase of boiler capacity brought about by the new equipment permits postponing cutting in the fourth boiler until after 5:30 p.m. If the duration of the tests had been 24 hours, it is probable that the comparative showing would not be essentially changed, since a like improvement has been made in the time of changing from the night to the day load in the early morning.

TEST DATA AT PLANT OF KNOXVILLE RY. & LIGHT CO.

	First test	Second test
Date of test	March 29	May 5
Duration of test, hours	11	11
Boilers fired, Babcock & Wilcox (No. 1 for 1 hour, Nos. 2, 3, 8)	1	2, 3, 8
Grate surface, square feet	270.0*	262.5
Heating surface, square feet	14,964	14,520
Ratio heating to grate surface	55.3:1	55.3:1
Steam pressure, pounds gage	157	160
Draft gage near stack, inches of water	0.32	0.29
External air, degrees Fahrenheit	45	65
Boiler room, degrees Fahrenheit	64	72
Feed water, degrees Fahrenheit	186	190
Steam, degrees Fahrenheit	409.3	433
Fuel		
Kind of fuel	Jellico nut and slack	Jellico nut and slack
Size of coal		
Moisture, per cent	2.77	2.96
Ash, per cent	10.6	14.1
Heat value per pound of coal, B.t.u.	13,528	13,091
Heat value per pound of combustible, B.t.u.	15,150	15,320
Total coal consumed, pounds	74,213	56,700
Dry coal consumed, pounds	72,158	55,008
Total ash dry, pounds	7,817	7,970
Total combustible, pounds	64,341	47,038
Total Water		
Total weight of water used, pounds	557,850	546,400
Total evaporation dry steam, pounds	557,850	546,400
Superheat, degrees Fahrenheit	40.7	63.0
Factor of evaporation	1.102	1.104
Equivalent evaporation from and at 212 degrees	614,750	603,220
Economic Evaporation		
Actual evaporation per pound of dry coal, pounds	7.73	9.93
Equivalent evaporation from and at 212 degrees per pound of dry coal, pounds	8.52	10.96
Equivalent useful evaporation per pound of dry coal (deducting steam used for jets), lb.	8.52	10.52
Actual evaporation per pound of combustible, pounds	8.69	11.62
Equivalent evaporation per pound of combustible, pounds	9.58	12.83
Equivalent useful evaporation per pound, pounds	9.58	12.23
Horsepower		
On basis 34½ pounds equivalent evaporation per hour	1,615	1,590
Corrected for steam used by jets		1,526
Builders' rating	1,854	1,800
Ratio, commercial to builders' rating	87.0	85.0
Electrical Output		
Kilowatt-hours	16,950	15,925
Kilowatts per hour	1,540	1,450
Efficiencies		
Heat supplied per pound of dry coal, B.t.u.	13,528	13,091
Heat absorbed per pound of dry coal, B.t.u.	8,228	10,160
Efficiency of boiler, per cent	61.1	77.7
Efficiency of boiler and grate	60.8	77.8
Overall efficiency of plant, per cent	5.94	7.54
Economic Performances of Plant		
Coal per kilowatt-hour, pounds	4.38	3.56
B.t.u. per kilowatt-hour, pounds	57,600	45,560

*As No. 1 boiler was feeding steam into the line for only one hour, or $\frac{1}{11}$ of the time, the grate surface of three boilers, 262.5 square feet for 10 hours, and 262.5 square feet plus 87.5 square feet (boiler No. 1) for one hour, is taken as equivalent to 262.5, plus $\frac{1}{11}$ of 87.5, or 270 square feet, for eleven hours. The same applies to the heating surface.

Station Records

The station records are as follows:

Date	Pounds of Coal	Total Kilowatt-hours Generated	Pounds of Coal per Kilowatt-hour
Jan., 1910	3,958,000	960,948	4.12
Feb., 1910	3,646,000	826,604	4.42
Mar., 1910	3,680,000	876,322	4.20
Apr., 1910	3,576,000	854,519	4.18
May, 1910	3,816,000	860,368	4.43
June, 1910	3,506,000	855,756	4.09
July, 1910	3,734,000	879,700	4.24
Aug., 1910	3,788,000	908,640	4.16
Sept. 1910	4,648,000	1,086,640	4.27
Oct., 1910	4,746,000	1,084,834	4.37
Nov., 1910	4,354,000	1,054,529	4.13
Dec., 1910	4,864,000	1,141,964	4.26
Average for 1910			4.24
May, 1911	3,356,000	939,000	3.57

FIG. 2. USUAL APPEARANCE OF KNOXVILLE RAILWAY & LIGHT CO.'S STACKS BEFORE INSTALLING JETS

FIG. 3. AVERAGE APPEARANCE OF STACKS SINCE INSTALLATION OF JETS

In analyzing these figures it is of interest to note first the close agreement between the coal consumed during the second evaporative test, 3.56 lb. per kilowatt-hour and that consumed during the entire month of May, 3.57 lb. per kilowatt-hour.

In accordance with the terms of the contract, the saving effected could justly be calculated by comparison with the fuel consumption for May, 1910. On this basis the saving would appear to be 19.4 per cent. However, this is not a fair comparison, since the operating characteristics of the plant in May, 1910, were not as favorable as during May, 1911. Comparing the fuel consumption for May, 1911, with the average for the year 1910, the saving figures 15.8 per

cent., and this might well be regarded as a fair comparison. For the sake of finding a perfectly impartial basis of comparison, however, the complete station records were searched with a view to selecting a month during which the operating characteristics were identical with those of May, 1911. The records for May, 1909, meet these conditions, 3,410,000 lb. of coal being burned and

blowers had not been used for 36 hours. In spite of this fact, the boiler performance was as good as that shown for the rest of the month, when the tubes were blown twice daily. This is so because the steam jets themselves kept the tubes clean. Before the first test the soot blowers had not been used for 36 hours. The fact that the boiler performance on this day was below the average perform-

consists of one 160-hp. Heine, one 200-hp. and three 150-hp. Stirling boilers, giving a total capacity of 810 b.hp. The contract for the smoke-consuming equipment was similar to that previously described; but the mills had no adequate record of their coal consumption.

The methods of the evaporative tests were the same as those used at the Knoxville Ry. & Light Co.'s plant.

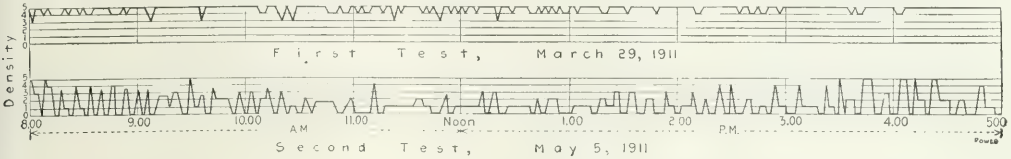


FIG. 4. RINGELMANN SMOKE CHARTS, MADE DURING TESTS AT KNOXVILLE RAILWAY & LIGHT CO.'S PLANT

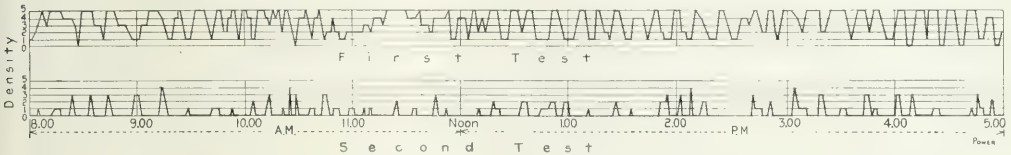


FIG. 5. RINGELMANN SMOKE CHARTS MADE DURING TESTS AT THE KNOXVILLE COTTON MILLS

315,400 kw.-hours generated, giving a coal consumption for the month of 4.18 lb. per kilowatt-hour. This yields as a final figure a saving of 14.6 per cent. A comparison of the average cost for the time which has now elapsed since installing the smoke consumers, with the

ance for 1910 proves simply that the tubes were badly coated. Hence the evaporative tests are of interest chiefly in that they bring out the service rendered by the smoke consumers in keeping the boiler tubes free from soot.

Results similar to the case just de-

Although the load carried by the plant is less than 550 b.hp., it has been the practice to carry the entire battery under steam, since with the quality of coal used steam could not otherwise be held. During the test with the consumers in operation, however, it was found an easy

FIG. 6. KNOXVILLE MILLS 60 SECONDS AFTER FIRING; STEAM JETS NOT IN USE

FIG. 7. KNOXVILLE MILLS 60 SECONDS AFTER FIRING, WITH STEAM JETS IN OPERATION

average for the previous 16 months, strikingly confirms this figure.

It remains to reconcile this 14.6 per cent. with the 20.9 per cent. saving apparently shown by the two evaporative tests. Before the second test the soot

scribed were obtained with steam jets in the boilers of the Knoxville cotton mills.

KNOXVILLE COTTON MILLS

The boiler equipment of these mills

matter to carry the load with the 200-hp. boiler cut out, notwithstanding that poorer coal was used than for the first test.

The degree of smoke abatement secured was better than that in the first

case described. This is shown both by a comparison of the smoke charts, Fig. 5, and of the photographs of the chimney, Figs. 6 and 7. No. 5 smoke did not occur at all with the consumers operating, and No. 4 occurred but four times during the entire nine hours of the test. On the other hand, the fuel saving is somewhat less. Figured on the basis of the B.t.u. supplied per pound of water evaporated, the saving would appear to be 14.8 per cent., but allowing that 3 per cent. of the water evaporated was consumed by the steam jets themselves, the final calculation shows a saving of 11.5 per cent.

TEST AT KNOXVILLE COTTON MILLS

	First Trial	Second Trial
Duration of trial, hours	9	9
Number of boilers fired	5	4
Grate surface, square feet	175.5	131.5
Heating surface, square feet	779.0	579.0
Steam pressure, pounds gage	115	116
Draft at breeching, inches of water	0.17	0.19
External air, degrees Fahrenheit	82	85
Boiler room, degrees Fahrenheit	94	107
Feed water, degrees Fahrenheit	192	189
Steam, degrees Fahrenheit	337	347
Kind of coal	bituminous nut and slack	
Size of coal		
Moisture, per cent	2.17	2.88
Ash, per cent	11.2	12.7
Heat value, per pound of dry coal, B.t.u.	13,153	12,790
Heat value, per pound combustible, B.t.u.	14,850	14,650
Total coal consumed, pounds	20,313	18,188
Dry coal consumed, pounds	19,800	17,640
Total ash, pounds	2,305	2,340
Total combustible, pounds	17,495	15,325
ECONOMIC EVAPORATION		
Actual evaporation per pound of dry coal, pounds	7.35	8.85
Equivalent evaporation from and at 212 degrees, per pound of dry coal, pounds	8.20	9.42
Actual evaporation per pound of combustible	8.75	10.20
Equivalent evaporation from and at 212 degrees, per pound of combustible, pounds	9.27	10.85
HORSEPOWER		
On basis 34½ pounds equivalent evaporation per hour	525	537
Builders' rating	810	610
Ratio of commercial to builders' rating, per cent	65	88
EFFICIENCIES		
Heat generated per pound of dry coal	13,153	12,790
Heat absorbed per pound of dry coal	7,919	9,097
Efficiency of boiler and grate	60	71.2
B.t.u. per pound of water evaporated	1,747	1,489

From the results of these and other tests which the writer has had the opportunity of making, he feels that the utility of steam jets, when properly controlled, has been established beyond question. The earlier reports, which were not favorable to the use of steam jets, were based either on tests made with steam jets not automatically controlled or else on tests of plants in which coal low in volatile matter was burned. Hand-operated steam jets will never serve effectively to prevent excessive smoke and do so with the highest economy; nor will automatically controlled steam jets effect any such saving of fuel as here reported if used with low-volatile coals. But the amount of smoke produced by a coal, and consequently the need for equipment to abate the smoke, increases as the volatile content of the coal increases; and so in general it may be said that the worse the offense of a plant in respect to smoke production the greater is the hope of its ultimate reformation.

Why "Block" Stations Do Not Thrive

By Henry D. Jackson

The main reason is because central-station rates are lowered temporarily to stifle them. Another reason is the lack of belief as to the possibilities of the "block" station on the part of those whom it is intended to serve.

In the issue of Nov. 14 an editorial appeared entitled "The 'Block' Central Station," which mentioned a scheme often thought of, frequently tried and in many cases proving a decided success. Wonder was expressed in the editorial that there are not more such plants, even though they have not proved a success in many other places than New York City. It may be that the experience of the writer in a number of instances will explain why it has been found so difficult to organize and carry through a successful "block" plant.

In those large cities where the central station is firmly planted, it is difficult to carry through any "block"-plant scheme because of the required coöperation of so many interests. For instance, in a large block having many tenants, each tenant has a contract for lighting, and possibly for power, with the central station, the price of the power varying in accordance with the service rendered. The organizer of a "block" plant suggests to the tenants or owners the possibility of a central-power plant for furnishing light, power and heat, the whole to be worked out on a coöperative basis. Or he suggests that someone will install a plant from which will be furnished light, power and heat at a reasonable price; that the price will be much lower than that of the central station because the tenants can obtain a considerable return from the exhaust steam which will be supplied from the engines driving the generators using it for heating purposes. The organizer carefully studies the light, power and heat demands of the tenants or owners, and then proposes that each owner or tenant agree to pay for a proportionate part of the power, light and heat used, the porportion being first as regards the meter showings for the various purposes and then to the radiation used for the heat; or he shows how the individual who installs the plant can furnish light, power and heat at a low cost, giving these figures to the individuals interested.

At first the individuals are decidedly interested, and state that they will take hold and push the scheme. Almost immediately, however, one of them takes the matter up with the central-station people, telling them exactly what is proposed; thereupon the central station immediately lowers its rates for light and power to the figure proposed by the promoter—in some cases to an even lower figure—with the result that when the promoter next visits the individuals, he finds that they are unwilling to entertain his scheme.

The central station rarely makes a contract for more than a year under these conditions, the scheme fails and the price for power and light goes back to the normal figure.

Briefly, the reasons why the "block"-plant scheme has not always proved a success are:

1. The short-sightedness of the owners or lesses of the property in the block, who cannot see that the low figure given by the central station is only an expedient to choke off the "block" plant.

2. The apparent lack of belief of the individuals in the possibilities of power being furnished at any such price, largely owing to the representations of the central-station solicitors and also the individuals' lack of technical information.

3. The unfortunate condition of affairs that exists whereby the central stations are enabled to sell power below cost to large consumers and charge the excess up to the small ones.

This condition is frequently found in large cities, where the central stations are strongly intrenched. They make the claim that power during the day, and in very large quantities, costs them nothing but the operating expenses during this period, as the interest, maintenance and

depreciation on the machinery, buildings, etc., are paid for during the lighting load. This is true only to a very limited extent, because the lighting and the power load do overlap to such an extent that it is only reasonable and fair that a considerable portion of the fixed charges should be made on the power bill, and the lighting commission in fairness to all consumers should take this attitude.

In one instance which came to my notice in the suppression of a "block" plant by the central station there was a large establishment which supplied light for the entire block, power for its own service and steam from heating and manufacturing purposes. A very fair profit was made from the sale of light and heat. The central-station solicitor, to secure this large block, made a proposition to the owner, who was not a steam or electrical expert.

He was informed that the larger part of the steam used was required for driving the electrical apparatus and that he was not making the amount of money he thought he was; that if he would put in electric power at a price slightly lower than he figured it cost him, he would save a very considerable sum; that his heat was costing him the most money. The owner believed him, dismantled his plant and put in central-station power. Much to his surprise, after the first year's operation, he found that the total bill for heating, lighting and power was very nearly double what it had ever been, including, as he did, all of his fixed charges.

To the technical man the reason is clear. His heat, both for manufacturing and heating, was formerly provided by exhaust steam, and sufficient exhaust steam was at all times available from the operation of his engine, so that he was practically supplying his heat for nothing. He was getting a fair price for his electricity and made a profit on it. On the removal of his generators he still had to supply the heat. The boiler capacity was the same as before, requiring the same amount of coal and the same amount of labor. The only difference was that he was not paying fixed charges on the difference between the price he paid for his generating apparatus and the price at which he sold it, and he was paying a price very nearly equal to what his electricity cost him in his own plant for what he purchased from the central station.

The remainder of the people in this block were worse off, because they got a contract for only one year, whereas the owner got a contract for ten years. This arrangement doubled the price of electricity at the end of the first year and the second year doubled again, so that they were very large losers by the deal. It is possible that under the conditions a "block" plant may again be installed in this block under a different owner, or perhaps the former owner will install his plant and continue to pay to the central station the present price for electricity. Even under these conditions there is a possibility of his making a saving, although the power company manages to hold him to the contract.

In some cases the central-station managers have seen the opportunities in the block plants, and have leased or bought space, installed apparatus and made arrangements to furnish electric power and heating to the people in the block. By this arrangement they are enabled to make a very comfortable saving over the price of power as generated from their own station and still hold up the price to the tenant. The saving is made because the plant is operated practically only during the winter months, when the peak load on the plant is excessive, and enables them to reduce the peak load, and as the heat of the exhaust steam is paid for, their operating cost can be lowered. In the summer time the plant need not be operated as the peak loads are practically noncoincident and the central station can very readily take care of all the load without marked peaks or excessive apparatus.

This system, if carried to its limit, would practically do away with the central station except that of comparatively small size. It would, however, soon result in the installation of block systems by the building owners or in a coöperative arrangement between building owners, and this is, in my opinion, the only reason why the central stations do not take it up more fully.

Peat

The results of an investigation that was undertaken to determine whether peat, a fuel widely used in some countries, could be serviceable in the United States are contained in a bulletin just published by the Bureau of Mines. Its author, Charles A. Davis, the peat expert of the bureau, gives an exhaustive review of the entire problem, both in this country and in Europe, and draws the conclusion that the peat beds of this country are a great and neglected resource, which, when fully developed, will add to the national wealth no inconsiderable quantity of good fuel and of raw material for important arts and manufactures.

Mr. Davis declares that the difficulties that have always been encountered in utilizing peat for fuel are due to the fact that in its natural state peat contains only about 10 per cent. of combustible matter, the remaining 90 per cent., more or less being water. He also says that in the last few years, more than $1,000,000 has been spent in erecting plants and in experimenting with peat, and that these efforts were unsuccessful.

"Because the closing of larger plants before they had reached a stage of demonstrated success was so general," says Mr. Davis, "more conservative developments have been planned for making a thorough trial of the material in favorably situated places under American conditions of production and fuel supply."

Mr. Davis estimates that there are more than 11,000 square miles of land in the United States having peat deposits of good quality; that these deposits contain 12,888,500,000 tons of peat with a value of more than thirty-eight billion dollars, enough peat to furnish heat and power for the entire country for many years.

The author is of the opinion that there will soon be a demand for peat as a fuel, at the same time he gives the following warning: "The foundation of all successful development and growth of peat industries in the United States must be a thorough scientific study of the occurrence, nature, qualities and peculiarities of peat itself and a careful and honest investigation of the status of these industries in the European countries in which they have reached self-supporting existence.

"It is an exceedingly interesting coincidence and a most important economic consideration that the regions where peat is most abundant are relatively remote from the coal fields, the only exception being the overlapping of peat and coal in Michigan. When one also notes that the more Northern states, in which fuel is most needed, and the parts of the Southern states where other kinds of fuel are not readily available, are rich in peat, it seems strange that a more careful examination into the possibilities of our peat resources has not been made, because potentially they have large value and great possibilities.

"Peat fuel may be said to be especially useful for certain purposes for which wood was formerly in general use and for which coal has not yet been altogether successfully introduced, such as brick and other forms of ceramic firing and lime burning. It appears to reach its highest value, however, as a source of producer gas in properly constructed gas producers.

"No quantity of peat fuel of any type sufficient to prove its value has yet been produced in the United States; until this has been done, although the outlook and European experience warrant further investigation of its possible uses and value, no final conclusions as to the commercial value of American peat as compared with coal can be reached."

To remove varnish, paint, tar or lacquer, or to restore a hard paint brush, the following mixture is recommended by D. L. Fagnan, of New York City: 4 oz. benzol, 3 oz. fusel oil, mix and shake well, then add 1 oz. of alcohol. This mixture will remove varnish in 10 min. and will soften a hard brush when soaked for 1 hr.

Application of Prof. Bone's Boiler

A boiler 10 ft. in diameter and 4 ft. long, capable of evaporating 5,500 lb. of water per hour, has recently been constructed for the Skinningrove Iron Co.

This boiler is similar in design to the experimental one with which an evaporation of 21 lb. per square foot of heating surface was obtained.

The experiments of Prof. Bone, of the University of Leeds, upon surface combustion appear to have attracted more than a passing interest in engineering circles, and if their application in actual practice bears out the results attained in the laboratory, the subject will undoubtedly have a potent influence upon present boiler practice.

In the Nov. 21 issue, space was devoted to the principles of surface combustion and to a description of Prof. Bone's experimental boiler with which he was able to obtain an evaporation of over 21 lb. of water per square foot of heating surface, at an efficiency of nearly 95 per cent.

Following these extraordinary results, comes the announcement that a boiler of the same type, but of larger size and capable of evaporating at least 5500 lb. of water per hour, has recently been constructed for the Skinningrove Iron Co., of Yorkshire. This boiler, which is shown in Figs. 1 and 2, as erected in the shops of the builders, Richardson & Westgarth, is 10 ft. in diameter, 4 ft. long and contains one hundred and ten 3-in. tubes. It is to be fired with byproduct coke-oven gas which will be drawn through the boiler by a fan capable of producing a suction equivalent to 20 in. of water. The products of combustion, having traversed the boiler tubes, pass to a semicircular chamber at the back of the boiler (see Fig. 2), thence through a duct to the economizer; the fan, which is attached to the economizer, discharges them through a short duct to the atmosphere. No stack is required.

For the benefit of those not having read the previous article upon the subject, it might be well to review briefly the principles of surface combustion and the results attained with Prof. Bone's experimental boiler. Surface combustion is based upon the fact that a mixture of gas and air, in the proper proportions for complete combustion, is caused to burn without flame when in contact with a granular incandescent solid, the combustion taking place only in the layers next to the incandescent surface, providing the mixture is fed at a velocity greater than the propagation of backfire.

The advantages claimed for this system are, (1) the combustion is greatly accelerated by the incandescent surface, and if so desired, may be concentrated just where the heat is required; (2) the combustion is perfect with a minimum excess of air; (3) the attainment of very high temperatures is possible without the aid of elaborate regenerative devices; (4) owing to the large amount of radiant energy developed, transmission of heat from the seat of combustion to the object to be heated is very rapid.

Applying these principles, Prof. Bone designed and built his experimental boiler (see Fig. 3), the main features of which will herein be reiterated. It consists of a cylindrical shell traversed by ten 3-in. tubes, 3 ft. in length. These tubes are packed throughout their length with fragments of refractory material, and into the front end of each tube, where the gaseous mixture is introduced, is fitted a fireclay plug, through which is bored a circular hole of about ¾ in. diameter. This plug serves the double purpose of keeping the front end of the boiler cool and of providing a suitable aperture through which the gaseous mixture may be introduced at a speed very much higher than the speed of back-firing.

Attached to the front plate of the boiler is a mixing chamber of special design, the mixture as fed into the tubes from this chamber containing a proportion of air very slightly in excess of that required for complete combustion. The mixture is injected or drawn in (either by pressure or by suction) through the orifice in this fireclay plug, onto the incandescent material in the tubes. The combustion is completed by the time the mixture has traversed a distance of about 6 in. from the point of entry to the tube, the remainder of the material acting as a baffle for the burnt gases and causing them to impinge repeatedly on the walls of the tubes. The gases leave the boiler at a comparatively low temperature (about 450 deg.) and then pass to a short

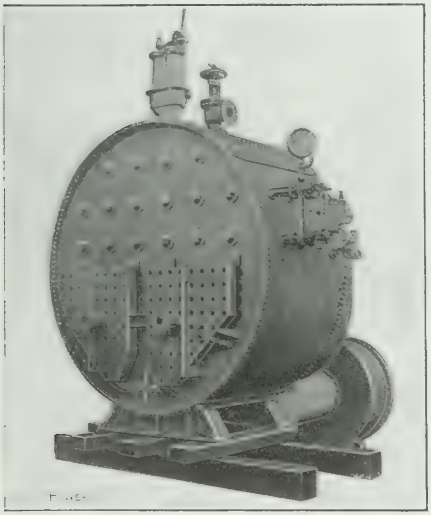


Fig. 1. Front View of Boiler

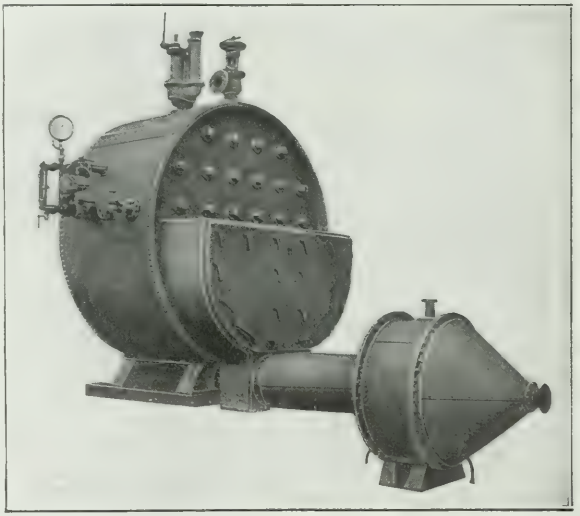


Fig. 2. Rear View of Boiler and Economizer

tubular feed-water heater or economizer at the rear of the boiler, finally emerging at a temperature of about 200 deg. F. with the feed water at 130 deg.

When starting up, air alone is admitted to the chamber *C* by means of the tubes *A* and gas alone to the chamber *D*, by means of the tubes *B*. The small tubes *F* convey the gas to the centers of the fireclay bushes in the several tubes and it is ignited as it issues from the left-hand or free ends of the boiler tubes, and the gas and air supply adjusted until the flame strikes back and combustion proceeds in the bed of fireclay. When the mass has become incandescent the gas supply to chamber *D* is shut off and through the pipes *A* a combustible mixture of gas and air is admitted. The separate admission is necessary at first to prevent the backfiring of an explosive mixture during the starting-up process.

Tests of this boiler using a mixture of Leeds coal gas and air introduced at a pressure of 17.3 in. of water, showed an evaporation of 21.6 lb. of water per square foot of heating surface into steam at 100 lb. and a combined boiler and economizer efficiency of 94.9 per cent. This exceptionally high efficiency may be accounted for by the very small excess of air, the complete combustion and the small radiation losses. The gases left the economizer at 203 deg. F. and the feed water entered boiler at 136 deg.

From a structural point of view, this boiler possesses certain advantages: No chimney is necessary, and being supported upon a casting, no elaborate setting is necessary. Furthermore, the front head can never be heated beyond the temperature of the water, which, with the short length of tubes, implies an absence of strain and greatly reduces the liability of leaky joints. Of course, its short length necessitates a greater diameter, but this is largely compensated for by the high rate of evaporation. With a mean evaporation of over 20 lb. per square foot of heating surface, it is estimated that about 70 per cent. occurs over the first third of the tube length, 22 per cent. over the next third and 8 per cent. over the remaining third. Such a steep gradient should cause a rapid circulation of the water within the boiler.

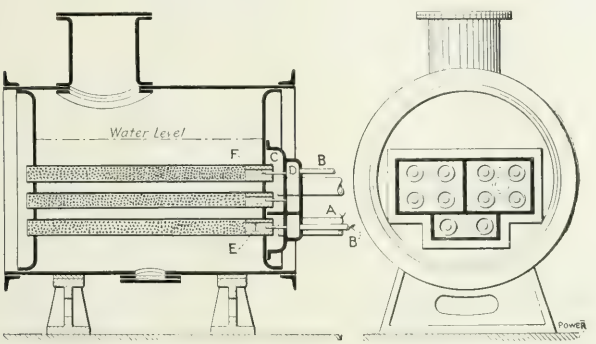


FIG. 3. EXPERIMENTAL BOILER

Electrical Reduction for Ship Propulsion

Before the united engineering societies of Boston, W. L. R. Emmet, of the General Electric Co., spoke upon the above subject with which his name has become identified by the contribution of numerous papers and discussions. His talk was informal and was based upon his former utterances. Mr. Emmet certainly makes out a strong case for electrical transmission between the turbine and the propeller.

It is often asked why motors should be used when in certain cases mechanical gearing has been successfully applied to speed reduction for this purpose, and it is not easy to give a definite answer to this question, since the limits of the application of gears are as yet very imperfectly understood. In this connection, said Mr. Emmet, it must be borne in mind that the performance of large high-speed gears must be considered as problematical, while the facts of electric speed reduction are established and certain.

The only ship that is being successfully propelled by gears is the S.S. "Vespasian," equipped by Sir Charles Parsons two or three years ago. This vessel operates with a single screw, to which 1000 hp. is delivered by two turbines. Each of these turbines drives a pair of helical pinions, the diameter of these pinions being 6 in. The diameter of the large gear, which is mounted upon the propeller shaft, is 10 ft., the speed reduction being 20 to 1. The face of each half of the pair of pinions Mr. Emmet did not know exactly, but his recollection was that it is about a foot, giving 2 ft. of working pinion length for each turbine shaft. The propeller operates at about 80 r.p.m. and the turbine at about 1600 revolutions per minute.

The speaker made a comparison between this case and the case of a large electrically propelled ship where the total horsepower is 17,000, delivered to twin shafts. The propeller speed is 84 r.p.m. and the turbine speed is 1800 r.p.m.

If each of these shafts were driven through gearing by two turbines, as in the case of the "Vespasian" shaft, each of the four turbines so used would have to deliver 4250 hp., and it is obvious that it would not be possible to deliver so large an amount of power to a pinoin having a diameter of only 6 in. If this were so, it would be necessary to greatly increase the length of the pinion in order that the pressure between teeth may be kept down. If the length of the pinion is increased, the strain imposed upon it will cause it to exert all its force at the driven end, the torsional elasticity of the pinion being such as to entirely relieve the opposite end from pressure. Thus to make a long pinion operate throughout its length, sufficient diameter must be had to give the necessary torsional stiffness, and theoretically it is impossible to conceive of a pinion which will not tend to bear harder at the driven end than it does at the opposite end.

If to avoid these difficulties the diameter of the pinion is increased, its peripheral velocity must also be in-

SHIPS FOR WHICH ELECTRIC PROPELLING MACHINERY HAS BEEN DESIGNED

Vessel	Displacement	Shaft Horsepower	Approximate Weight, Main Engines or Turbines, Tons	Weight, Corresponding Electric Drive, Tons	Speed, Knots	R.p.m., Electric Drive	Water Rate, Electric Drive without Auxiliary, Pounds per Steam Horsepower	Steam Conditions
"Cyclops"	19,360	6,850	335	135	14	110	12.0	200 lb. gage, 28.5" vac. dry
"P.S. 445"	25,000	12,500	411	237	16	110	11.5	200 lb. gage, 28.5" vac. dry
"Delaware"	20,000	3,400	435	374	12	87	12.85	260 lb. gage, 28.5" vac., 50 deg. superheat
		17,300	435	374	20	148	11.5	260 lb. gage, 28.0" vac., 50 deg. superheat
"Everett"	10,945	2,275	102	55	10.5	85	13.0	175 lb. gage, 28.0" vac., dry
"Otaki"	9,900	5,500		133	15.6	114	12.5	181 lb. gage, 28.0" vac. dry
Unnamed		17,000	910	430	17.5	84	11.0	190 lb. gage, 28.5" vac. dry

creased or it will be necessary to diminish the speed of the turbine which drives it or increase the diameter of the large wheel, and any of these changes may involve serious difficulties. As the parts of such a structure are made larger, the difficulty of maintaining perfect accuracy of engagement between them increases, and the weights and spaces occupied are rapidly multiplied.

Some engineers who are advocating the use of gearing for ship propulsion have proposed the use of peripheral velocities in some cases double that used upon the "Vespasian," but even with these extreme assumptions the gearing for such a ship would be a very formidable affair, and it would be necessary either to diminish the turbine speed or increase the propeller speed to keep its proportions within reason. Even if the gearing itself involved no loss, it is probable that the necessary disadvantages in the turbine and propeller would more than offset the electrical losses which must be incurred if Mr. Emmet's method is adopted. The total electrical loss in such a ship as the "Vespasian" amounts to only 8 per cent. and this loss constitutes the only valid argument which can be brought against electric propulsion as compared with propulsion by gearing. With an electric propeller it is known that both the turbine and the propeller can be operated at the most advantageous speeds, and that all the advantages incident to doing so can be gained; with mechanical gearing, there is no such knowledge, and the facts actually demonstrated fall very far short of such an ideal.

The accompanying table gives approximate figures concerning the number of ships of different types for which electric propelling machinery has been designed.

The Passing of One of Corliss' First Engines

In his paper, "The Power System of the Pacific Mills," presented at a recent meeting of the Boston Society of Civil Engineers, the Mechanical and Electrical Engineers coöperating, Fred A. Wallace, to whom we are indebted for the drawings reproduced herewith, drawn by him largely from memory, made a forcible comparison between the prime mover of today and that of the middle of the past century, emphasizing it by a description of one of the original engines of the Pacific Mills, which was torn down in the reorganization for the new central power plant.

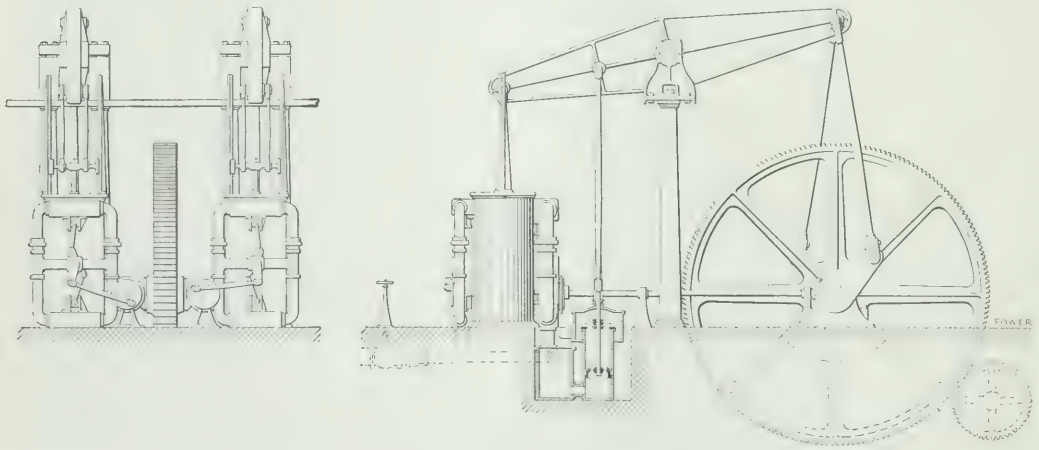
The double walking-beam engine which was removed by these changes was, for sentimental reasons, torn down with regret, said Mr. Wallace. As this was an engine designed over 60 years ago, a description may be interesting. It was of the double walking-beam type, having two vertical cylinders 38x40 inches, both operating condensing. The flywheel has a gear 20 feet in diameter and 18 inches face, having a pinion on the waterwheel jack shaft. The engine in its general appearance was like the famous Centennial engine but not so elaborately finished. It was built by Nightingale, Bancroft & Co., of Providence, R. I., in 1847, and was one of the first engines in which George H. Corliss was interested. It was made before the rotary cutoff valve was invented and the valves were plain slides, one inlet and one exhaust on each end of the cylinder. They were operated from a gear on a lay shaft. The engine was built to operate with 30 pounds steam pressure and to run at 30 revolutions per minute; the speed was controlled by a throttling governor. Although designed for 450 horsepower, it has developed 900 horsepower. The condenser was of the jet type, of the simplest form, as shown in the sketch. The pump was a common bucket arrangement 24 inches in diameter by about 36 in. stroke, with two large brass valves hinged in the center and each covering nearly one-half of the area of the piston. One single rubber valve 24 inches in diameter by 7/8 inch thick constituted the upper deck.

In 1897 this engine was overhauled and the valves were adjusted to run on low-pressure steam which was taken from an exhaust system into which nearly 100 engines and pumps of various sizes exhausted. Enough of this exhaust steam was used by the engine to produce about 350 horsepower and the remainder was used for manufacturing purposes.

The engine is thus further interesting in that it is one of the first large power units to run on exhaust steam. No tests were made to determine the efficiency, but it must have been very good under the conditions in which it was run. In the changing of this engine to low pressure and adjusting to increase its efficiency with a higher vacuum, the fact was realized that there is as much energy in a pound of steam expanding from atmospheric pressure to 27 inches of vacuum as when expanding from 120 pounds to the pressure of the atmosphere.

The engine was offered to several educational and other institutions in the hope that it might be preserved as an example of engineering before the advent of the Corliss type of engine, but its great bulk made it impossible to find a suitable home for it and it was reluctantly broken up.

It occupied practically three floors of a building 50x30 feet and developed nominally only 450 horsepower.



Double Walking-beam Engine Designed over 60 Years Ago

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Locating Defects in Direct Current Armatures

By Gordon Fox

The faults which most commonly develop in direct-current armatures are short-circuits, open circuits and grounds. The location of a short-circuit or an open circuit in an armature in service is usually self-evident. In case of a short-circuit in any coil or between commutator bars, excessive heat is developed in the affected coil, often causing smoke to be given off. By revolving the armature slowly by hand while still hot and feeling carefully of the armature-coil ends and commutator segments, it is quite easy to determine the hottest points and mark the coil in trouble.

In case of an open circuit in an armature in service, bluish green rings of fire will encircle the commutator. The mica strips adjacent to the bars to which the open coil is connected will be very noticeably pitted by the arcing across them. In a four-pole machine there will be two pitted strips located diametrically opposite each other. In a six-pole machine there will be three pitted strips 120 degrees apart.

The location of a ground can sometimes be detected by the odor of burnt insulation at the defective point. If the ground is only partial, a high potential impressed between the winding and the ground may cause an arc, which will betray the location of the trouble.

A simple device which may be used to locate accurately all "shorts," opens, grounds or cross-connections in any direct-current armature is illustrated in Fig. 1. The method of using it consists in inducing a small alternating electromotive force in the armature coils and then testing by means of a telephone receiver from bar to bar for defects. To induce the electromotive force in the armature coils, the U-shaped magnet, which has a laminated iron core, is excited with alternating current and the poles are applied to the armature core so that they are opposite the two sides of a coil. In order to make the magnet adaptable to different sizes of armature, the pole pitch may be made adjustable by hinging at the center, shortening half of the laminations, interleaving the others and fastening with a bolt passed through axially.

The cross-section of the magnet core should be about 2x8 in., the longer dimension being that parallel to the armature slots. For 110-volt alternating-current supply each coil should consist of about 60 turns of No. 6 double-cotton-covered wire wound over mica insulation on the core. Pins may be set into the core to hold the coils in place, as shown in Fig. 1.

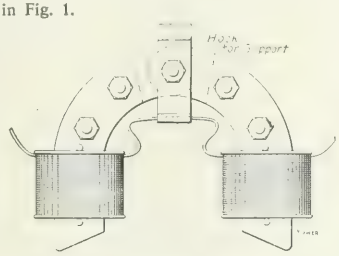


Fig. 1. Inducing Magnet

The magnet may be suspended from a small rope fall and lowered over the armature, which should be so supported on horses or in a lathe that it may be rotated. There should be about ¼ in. clearance between the pole tips and the armature core. Fig. 2 shows how the device should be applied. With the magnet thus located and its winding excited with alternating current, there is induced in the armature coils an alternating electromotive force; and a slight potential difference therefore exists under normal conditions between adjacent commutator segments. If a telephone receiver be connected from one bar to the next adjacent bar, a small alternating current will flow through it, setting the diaphragm into vibration, and a humming sound will result.

In case a short-circuit exists between the bars being tested, there will be no voltage difference between them and the receiver will indicate the short-circuit by failure to vibrate. In case of a short-circuit between two turns of a multi-turn coil, the humming of the receiver will be decreased considerably, depending on the number of turns short-circuited. A cross-connection is indicated when groups of three or four bars symmetrically spaced test silent. A few top coil sides must be lifted out of the slots and tested out to determine the exact location.

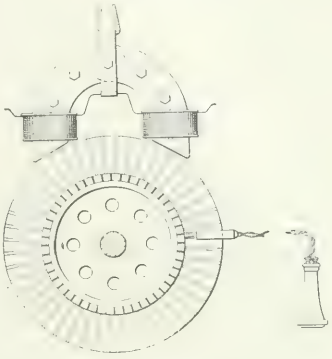
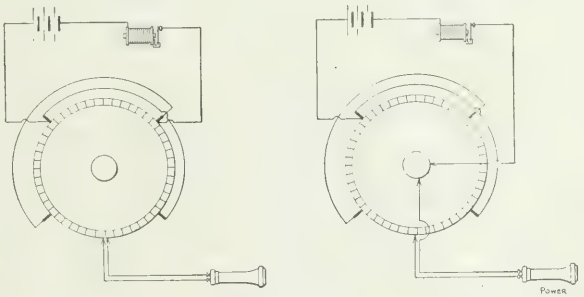


Fig. 2. Application of Magnet and Explorer

When an open circuit exists, a comparatively large potential difference results between the bars connected to the defective coil. Consequently, the receiver responds with a loud click when such a point is reached. A dead ground is merely a short-circuit between some coil and the core. It can therefore be located by the short-circuit method, connecting one receiver terminal to the shaft and testing each segment with the other. If the armature is grounded, the receiver



Figs. 3 and 4. Substitute for Inducing Magnet

will test silent on the bars connected to the grounded coil. On the other bars a sound will result and its intensity will decrease as the grounded bar is approached. This test can only be used when a dead ground exists.

In using this method of testing for faults, care should be taken to keep the position of the magnet at all times the same with respect to the armature core and the telephone terminals; otherwise, the effects of varying field strength may lead to erroneous conclusions. A pair of exploring terminals* should be used and kept in one position, the armature being slowly rotated to change the segments under test.

Although this is an excellent method for use in a repair shop, it is not always practicable, due to the requirement of a special exciting magnet. A modification of this method, however, can be easily applied to any direct-current armature without removing it from its bearings. A storage battery or a few dry cells and a buzzer may be used to replace the inducing magnet. The battery and buzzer are connected in series and the terminals placed under brushes of opposite polarity, as represented in Fig. 3. The exploring terminals attached to the receiver are then placed on the commutator about midway between brushes and the armature slowly revolved, so as to test from bar to bar as previously described. The interrupted current acts similarly to the alternating current induced by the exciting magnet and the results are the same. It is difficult, however, to locate a short-circuit between turns by this method.

To locate a ground, one battery terminal should be connected to the motor frame and the other terminal left under one brush as before. The receiver terminals are connected to ground and to successive segments, as shown in Fig. 4. The receiver will test silent when the grounded bar is reached.

*See Fig. 6 and accompanying description on page 892, Dec. 12 issue of Power.

The Westinghouse Load-Equalizing Hoisting Set

The Calumet & Arizona Mining Co. recently completed an elaborate set of tests on an electric hoisting system which has been in operation some time at its mine in Bisbee, Ariz. The installation is reported as having been highly satisfactory in every respect and remarkable for the ease with which it is handled and the complete control which the operator has over it.

Tests have shown that even under severe operating conditions where the hoist is running a great portion of the time, the average intake of the system over a day's run will not be more than about 25 per cent. of the maximum load,

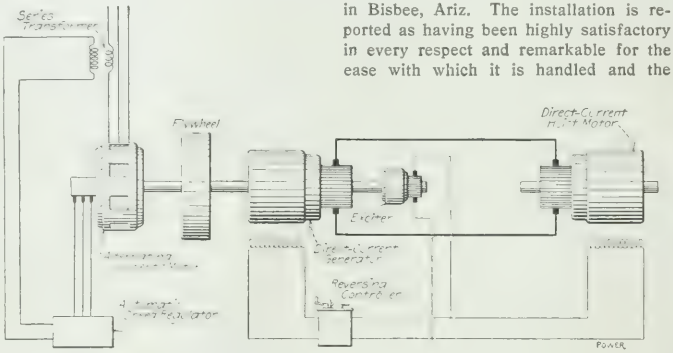


FIG. 1. DIAGRAM OF LOAD-EQUALIZING HOIST SYSTEM

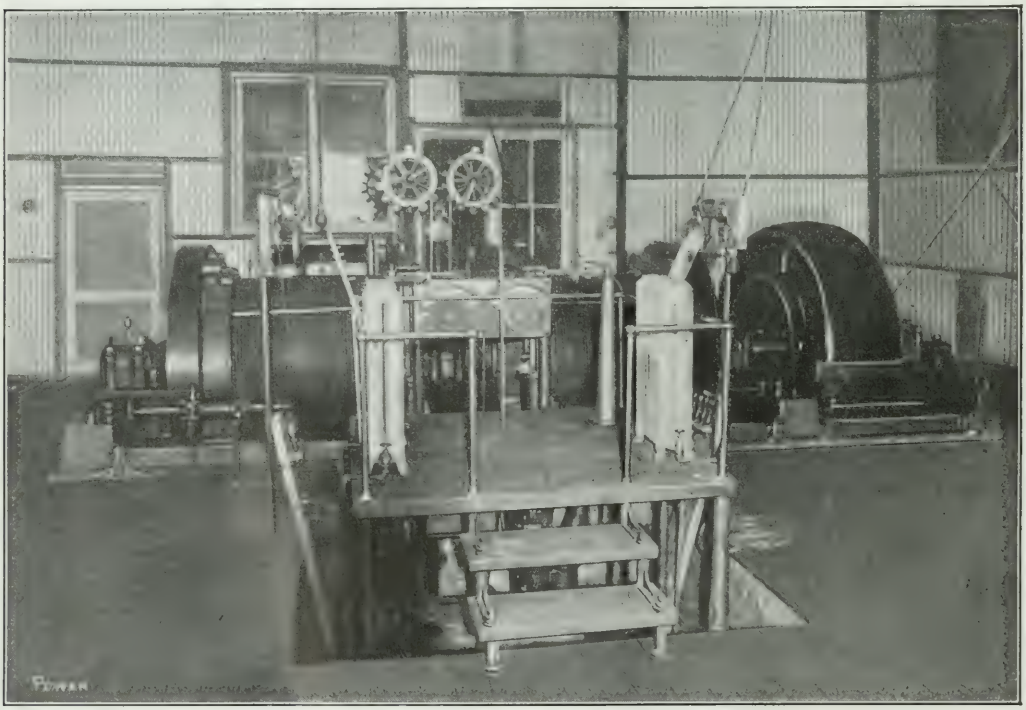


FIG. 2. THE HOISTING EQUIPMENT AND CONTROL APPARATUS

and that the rate of intake is practically constant.

With small hoists, it has been found satisfactory to use alternating-current induction motors directly applied, but where heavy loads are to be handled and at high speed, the peak due to the acceleration of the rapidly moving parts is always greatly in excess of the average requirements of the hoist. If the current is supplied from a line also carrying a lighting load, the resulting fluctuations of voltage prove most objectionable.

Furthermore, in most cases the hoist is at the end of a long transmission line and an excessive amount of copper must be installed to prevent a serious drop in the voltage during the maximum demand; in other words, the line must be equipped for the peak load instead of the average load, at a greatly increased expense.

It was to overcome these undesirable conditions that the Westinghouse load-equalizing hoisting plant was devised. The essential features of this system are diagrammatically shown in Fig. 1. The machinery consists of a direct-current motor direct-connected to the hoist drum, a direct-current generator and its exciter, coupled to an alternating-current induction motor, and a laminated flywheel mounted on the motor-generator shaft. The equipment also includes a reversing controller for the generator field winding, a speed regulator for the induction motor, a series transformer and a switchboard.

The hoist proper was built by the Denver Engineering Works, and it has a normal duty of 6000 lb. unbalanced load. Its hoisting speed is 1000 ft. per minute.

The brushes of the generator and the hoist motor are electrically connected, directly. The field winding of each machine is excited separately, constant full field being maintained in the motor. The hoist is started by gradually increasing the field strength of the generator and thereby delivering an increasing voltage to the hoist motor. When the load on the alternating-current motor reaches a certain point, resistance is automatically inserted in its secondary circuit, reducing the speed of the set, and the energy stored in the flywheel is used to overcome the peak of the hoisting cycle, economizing in the draft of current from the supply circuit.

The hoist is stopped by gradually weakening the generator field and thus allowing all excess energy in the descending cage, the rotating hoist motor and the drums to be returned to the flywheel through the generator, which momentarily acts as a motor, receiving energy from the hoist motor, which for the moment acts as a generator.

The overall efficiencies of hoists of this type are generally from 50 to 60 per cent. when operated under normal operating conditions.

Because of the ease of control and the general characteristics of the set, it is a simple matter to devise reliable safety devices which do not depend on mechanical brakes. Such devices have been put in practice in Germany, where the government allows men to be hoisted at a speed of 2500 ft. per minute in this type of hoist, whereas with steam hoists provided with the best available safety devices the maximum speed allowed is but 1200 ft. per minute.

The first cost of installation is, of course, somewhat greater than a small motor hoist with rheostat control, but the reduction of power cost due to the equalization of the load is said to be so great that the initial expenditure becomes a secondary matter, especially when power is purchased on any maximum-demand system.

Fig. 2 shows the hoist motor, the drums and the operator's platform at the Calumet & Arizona Co.'s Bisbee plant. The set consists of a Westinghouse 220-hp. shunt-wound interpole hoist motor, direct-connected to the hoist drum; a flywheel motor-generator which comprises a Westinghouse 180-kw. shunt-wound interpole direct-current generator, a 22,700-lb. laminated flywheel and a 180-hp. three-phase induction motor; a Westinghouse 15-kw. 125-volt exciter and, of course, the necessary controlling and regulating devices. The hoist motor runs at 63 r.p.m., maximum, when receiving current at 550 volts from the generator; the induction motor is a 60-cycle 220-volt machine and drives the generator normally at from 1050 to nearly 1200 r.p.m., the latter being synchronous speed.

LETTERS

An Easy Problem in Star Connections

Some time ago trouble with a polyphase wattmeter gave rise to considerable discussion which I should like to submit to the readers of POWER. Our system is a four-wire three-phase one and all of the switchboard instruments are supplied with current through current and potential transformers. Fig. 1 shows the connec-

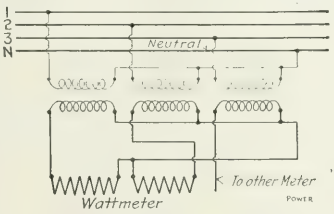


FIG. 1.

tions of the potential transformers and the potential coils of the wattmeter, as shown in the wiring diagram sent with the switchboard panel on which the meter is mounted. Fig. 2 is the same as Fig. 1 with one transformer left out, while Fig. 3 shows the connections as given in the meter instruction book.

I maintain that for all practical purposes the three diagrams are the same, but others say they are not; they contend that in Fig. 1 the transformers are Y-connected and in Fig. 3 they are con-

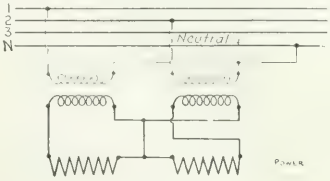


FIG. 2.

nected open delta. My opinion is that Fig. 3 is really an open Y-connection and that so far as the wattmeter is concerned will give the same results as Fig. 1. Who is right?

W. RUSSELL COOPER.

Indianapolis, Ind.

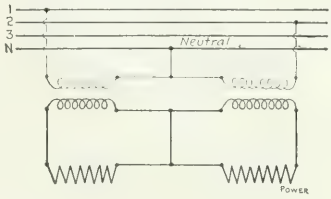


FIG. 3

[Fig. 3 is not the exact equivalent of Fig. 2; neither is it an open delta connection. No true delta connection is possible with transformer terminals connected to a neutral. The relations between Figs. 1, 2 and 3 are not difficult to analyze and we shall leave their analysis to the readers.—EDITOR.]

Rotary Converters vs. Motor Generators

I note in the Electrical Department of the Dec. 5 number a table by Mr. Tupper on page 854 purporting to give the best general practice as regards the use of motor-generators or rotary converters for various frequencies and direct-current voltages. In particular, he refers to the use of a motor-generator as preferable on a 60-cycle circuit with a direct-current voltage of 600. In the article he states that there is considerable trouble in the operation of converters at 60 cycles, flashing over and hunting being the chief troubles.

I do not know how far back Mr. Tupper has gone for his data. Not many years ago one company manufacturing machines of this character had a great deal of trouble with its rotary converters flashing over, also hunting, at about 600 volts on 60-cycle work. One of the other companies, however, manufactured

his class of apparatus which gave absolutely no trouble with voltages as igh as 650 and over on a tremendously arying railway load; and at the present time I believe many of the electrical ompanies can build converters for these onditions which will give service that vill compare favorably with 25-cycle peration. The chief difficulty with converters of this character is to get a low ifference of potential between commutator bars without having the commutator surface run at an excessive velocity.

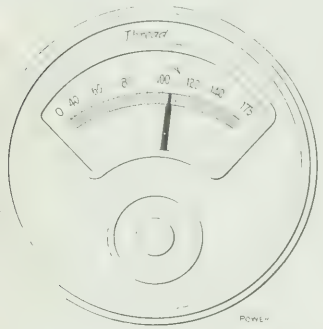
With the old-type converter, in which he field was comparatively weak and he neutral point was constantly shifting wing to the variable load, a great deal f trouble was experienced; also, when he converter was not provided with polepace grids or some other device to prevent the hunting. The modern converter, either with a strong, stable field nd grids or with interpoles, will give atisfactory operation on 60-cycle circuits and direct-current voltages of 600 nd considerably over. The only condiion under which a motor-generator is nore satisfactory than a rotary converter is that where a wide variation of irect-current voltage is essential. Rotary onverters can be compounded and oprated with perfect satisfaction where he voltage is to remain within moderate imits, and they have the advantage of eing far less costly and much simpler.

HENRY D. JACKSON.

Boston, Mass.

A Simple Way to Put an Index on a Voltmeter

A voltmeter that is not provided with n adjustable index to show where the eedle ought to point causes incon-



A HOME-MADE VOLTMETER INDEX

enience, if the voltage is likely to vary often, because one cannot tell from a listance whether the needle is at the ight point on the scale. To correct this lefect I put an index on my voltmeter. made a mark on the outside of the glass, with something that rubs off easily, at the point where I wish to keep the voltage. Then I took the glass out and glued a piece of thick black thread on the inside to agree with the mark on the outside and rubbed off the outside mark.

This has the advantage that cleaning the glass does not disturb the index, as it would if the thread were glued to the outside face of the glass. The accompanying sketch shows the index in place. This may not be new, but I have never seen it before and I have found it to be a great help in watching the voltmeter.

SAMUEL H. WINTERBOTTOM.

Woonsocket, R. I.

That Line Current Problem

In the Inquiries Department of the Nov. 28 issue, I noted with interest the answer to a request by "G. A. H." for a method of calculating the line current when the delivered voltage is not known. The formula given is correct, but the one given below is somewhat simpler and has the advantage of following the general equation:

$$Amperes = \frac{Watts}{Volts}.$$

My formula is:

$$Amp. = \frac{Watts}{\sqrt{\left(\frac{Volts}{2}\right)^2 - watts \times ?c} + \frac{volts}{2}}$$

MURRAY RANEY.

Springfield, Ill.

The formula given in the Inquiries Department in reply to "G. A. H.'s" question is, of course, correct, but it is not the easiest method of finding the desired current strength. The relation between the generator voltage, line resistance, delivered power and line current is:

$$Watts = Volts \times Amp. - Res. \times Amp.^2$$

and an easy way to find the value of the line current is to assume a low current value, a medium value and a high one and plot a small chart showing the relation between watts and amperes.

The accompanying chart illustrates what I mean. It is plotted from the figures given in the example which was stated in the answer to "G. A. H." The currents assumed were 20 amperes, 60 amperes and 100 amperes. At 20 amperes the delivered watts would be:

$$500 \times 20 - [illegible] \times 20^2 =$$
$$10{,}000 - 200 = 9800$$

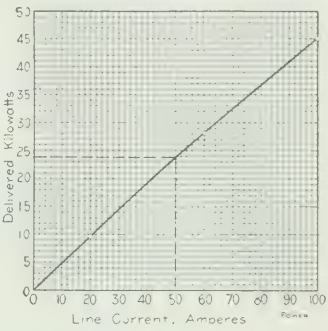
watts, or 9.8 kw. At 60 amperes, the delivered power would be

$$500 \times 60 - [illegible] \times 60^2 =$$
$$30{,}000 - 1800 = 28{,}200$$

watts, or 28.2 kw. At 100 amperes, the delivered watts would be 45 kilowatts.

Using a piece of ordinary cross-section paper, lay off a scale of amperes on the bottom and a scale of kilowatts up the side and locate one point at the intersection of the 20-ampere line and the 9.8-kw. line, another at the crossing of the 60-ampere and 28.2-kw. line, and the third at the crossing of the 100-ampere and 45-kw. lines. Then draw a curve through the three points and the zero point, as shown.

By tracing from any value of kilowatts over to the diagonal curve and thence



MR. WING'S CHART METHOD

down to the bottom scale, the corresponding current may be found.

This method is almost as short as solving the equation given, and the liability to error is much smaller.

STEPHEN R. WING.

Ithaca, N. Y.

Mr. Raney's formula is correct and is also less tedious to work with than ours, which was the conventional solution of the affected quadratic

$$Volts \times Amp. - Res. \times Amp.^2 = Watts$$

Mr. Wing's method is much quicker than the calculation, but it would be rather difficult to obtain accuracy with it if either the current or the delivered power should happen to be expressed in several figures and the values should not be easily located on a scale of relatively few divisions. For example, if the delivered power were 28,457 watts and the corresponding current 257 amperes it would be necessary to plot a very large chart to determine the values correctly. The method is excellent for approximations and for small values of current and delivered power.—EDITOR.

An important water-power development is now nearing completion on the Ocoll River, at Parkville, Tenn. A maximum head of 114 ft. has been made available by the construction of a concrete dam impounding the water so as to form a lake 2000 acres in extent. It is estimated that the development will yield about 32,000 hp., the power being transmitted at 66,000 volts to Cleveland, Chattanooga, Knoxville and other surrounding cities.

According to the United States Geological Survey, the coal output in this country for the year 1910 exceeded that of Great Britain by over 200,000,000 tons.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Coal Required to Heat Modern City Building

By E. F. Tweedy

The artificial heating of all habitable buildings throughout the greater part of the temperate zone is necessary during some six to eight months of the year, if inside temperatures conducive to the physical comfort of those who reside within are to be maintained.

Some idea of the relative importance of this heating problem in different sections of our own country may be obtained by referring to Fig. 1, which shows the mean monthly temperatures in a number of cities located in various parts of the United States.

This chart is based upon the assumption that artificial heating is required when the mean outside temperature is below 55 degrees Fahrenheit, and that the amount so required is proportional to the difference between 70 degrees Fahrenheit (the assumed inside temperature) and the mean outside temperature. The mean temperature for a given month is plotted upon a vertical line erected at the middle point of the corresponding month. Straight lines are drawn between the various points thus obtained, and from the two points where the horizontal line through 55 degrees Fahrenheit is crossed, vertical lines are erected to meet a horizontal line drawn through 70 degrees Fahrenheit. The areas of the polygons thus obtained roughly represent the heating requirements in the several cities which have been selected for comparison. The intercepts upon the horizontal line drawn through 55 degrees Fahrenheit give an approximate idea of the number of days comprising the heating season, for each city. Table 1 gives the mean monthly temperatures of these several cities, as well as the mean temperatures during the heating season and the number of days during which heating is required, both of the latter sets of figures being obtained from Fig. 1. The last line of this table gives the heating requirements of each of these cities as a percentage of those of New York City. In determining these relations, however, no allowance has been made for any differences in mean wind velocity, although this is a factor which may materially affect the heating requirements, as is shown later on. Furthermore, they make no allowance for those days, if any, during the heating season when either no, or only a small amount of, heating may be required, such as on Sundays, holidays, etc., and they therefore do not afford an accurate means of comparing the heating requirements of two given buildings located in different cities, if the operating conditions of these buildings, as regards continuity of heating, are radically different.

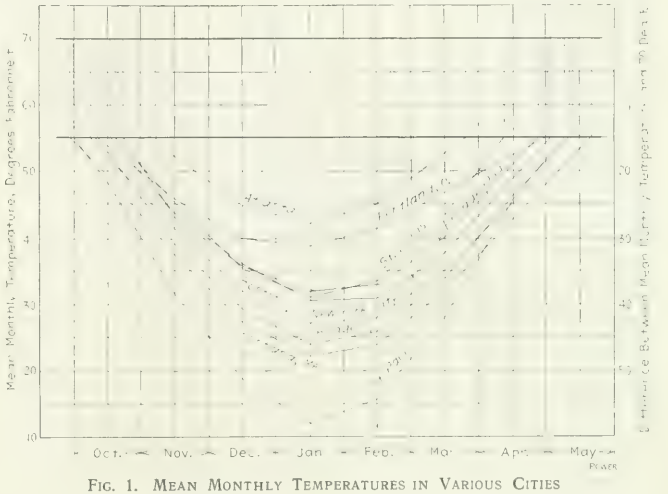


Fig. 1. Mean Monthly Temperatures in Various Cities

The loss of heat by transmission through the various materials of which modern buildings are composed, has been made the subject of much experimental study, and, as a result of the many investigations which have been made along these lines, it is now possible to predict, with a considerable degree of accuracy, the loss of heat which any given building will experience by transmission through its walls, roof, etc., for any given conditions as regards building exposures and outside and inside temperatures, when the nature of the materials of which the building is constructed, together with the thicknesses of such materials, is definitely known.

Table 2, compiled from data given by various authorities, shows the approximate amount of heat that is transmitted per square foot per hour for every degree difference in temperature between the inside and outside air for a few of the materials most commonly used in the construction of modern city build-

TABLE 1. MEAN MONTHLY TEMPERATURES

	Portland, Ore.	St. Louis, Mo.	St. Paul, Minn.	Atlanta, Ga.	Philadelphia, Pa.	Boston, Mass.	Portland, Me.	Chicago, Ill.	New York, N. Y.
January	38.7	31.0	11.9	42.2	31.8	27.0	22.0	24.0	30.6
February	41.4	33.5	15.4	45.2	32.8	28.0	23.8	25.7	30.7
March	46.1	43.5	28.2	52.4	40.0	35.0	32.0	34.9	37.8
April	51.8	56.1	45.8	61.1	50.8	45.3	43.0	46.2	48.7
May	57.7	66.5	57.7	69.5	62.2	56.6	53.5	56.6	59.8
June	62.5	75.1	67.2	75.6	71.2	65.8	62.6	66.5	69.0
July	67.3	79.1	72.0	77.6	75.8	71.3	68.0	72.3	74.1
August	66.6	77.2	69.7	76.1	73.8	68.9	66.2	71.3	72.6
September	61.3	70.0	60.5	72.1	67.4	62.7	59.6	64.8	66.5
October	53.7	58.4	48.4	62.4	56.3	52.3	49.1	53.1	55.6
November	45.7	43.4	31.0	51.9	44.9	41.2	37.6	39.4	43.9
December	40.2	35.5	18.8	44.6	35.7	31.6	27.1	29.1	36.0
Mean for year	52.8	55.8	43.9	60.9	53.6	48.8	45.4	48.7	52.1
Mean during heating season	49.9	43.1	35.4	54.4	44.1	42.3	41.1	41.5	45.0
Difference between 70 and mean during heating months	25.7	28.5	39.0	22.0	28.3	30.4	32.3	32.0	28.8
Number of days during heating season	203	178	223	139	190	216	234	212	197
Per cent. of New York City heating requirements	92	90	154	54	95	116	133	119	100

ings. The heat losses as given in this table are, when used as a basis for calculating the amount of radiating surface required, generally increased by some 10 to 20 per cent. when the exposure is a northerly one; by 10 to 30 per cent. when the building is heated during the daytime only, the percentage of increase depending upon whether the building is in a protected or in an exposed location, and by 50 per cent. when the building is heated only intermittently, with intervals of considerable duration when the building is without heat.

TABLE 2

BRICK WALLS

Thickness, in.	8	12	16	20	24	30	36
B.t.u. loss per sq.ft. per hr. per degree diff. in temp.	0.46	0.32	0.26	0.23	0.20	0.17	0.13

STONE WALLS (Sandstone)

Thickness, in.	12	16	20	24	28	36	44
B.t.u. loss per sq.ft. per hour per degree diff. in temp.	0.44	0.38	0.36	0.30	0.27	0.24	0.20

B.t.u. loss per square feet per hour per degree difference in temperature.

Single window	1.03–1.1
Double window	0.45–0.52
Single skylight	1.00–1.14
Double skylight	0.42

changes per hour for that portion of the building which is to be heated, but this method is uncertain at best and it may lead to considerable error.

In order to eliminate the uncertainty that arises from estimating the heat loss due to air leakage by assuming an arbitrary number of air changes per hour, the writer employs a method which combines this loss with the heat loss due to transmission, both being expressed in terms of equivalent glass. The possibility of making such a combination was arrived at by the following line of reasoning. The loss due to air leakage is proportional to the summation of the window perimeters (assuming the leakage space around the windows to be approximately constant in width), but as the dimensions of the windows in similar types of city buildings are fairly uniform, it becomes possible to consider the leakage loss as a function of the total window-glass surface, when deriving a general expression for the loss of heat from buildings of a given type, without introducing any considerable amount of error.

In reducing wall exposure to equivalent glass, a ratio of 4.5 to 1 has been taken as representing the relation which

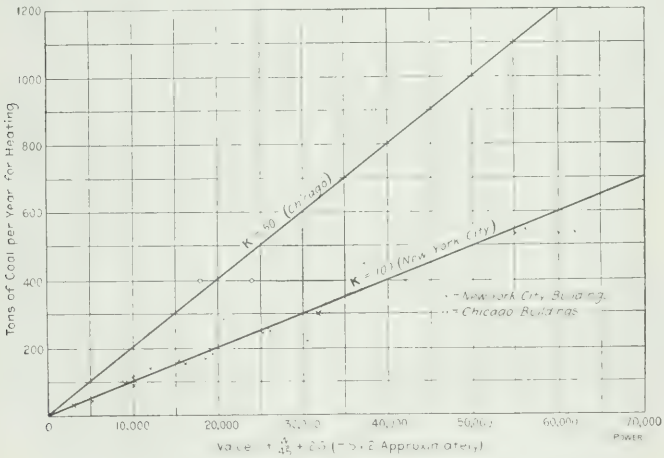


FIG. 2. ANNUAL COAL CONSUMPTION PLOTTED AGAINST TOTAL GLASS EQUIVALENT

The loss of heat occasioned by the leakage of air at the windows and doors is, however, not subject to precise calculation, and this loss may result in an insufficient amount of radiating surface being provided, unless proper allowance is made to cover this loss, either by basing the estimate upon previous experience or by following one of the more or less empirical methods that are frequently used in providing for the loss of heat due to this cause. The most common method of making provision for this loss is to assume an arbitrary number of air changes per hour for that portion of the building which is to be heated, but this method is uncertain at best and it may lead to considerable error.

In order to eliminate the uncertainty that arises from estimating the heat loss due to air leakage by assuming an arbitrary number of air changes per hour, the writer employs a method which combines this loss with the heat loss due to transmission, both being expressed in terms of equivalent glass. The possibility of making such a combination was arrived at by the following line of reasoning. The loss due to air leakage is proportional to the summation of the window perimeters (assuming the leakage space around the windows to be approximately constant in width), but as the dimensions of the windows in similar types of city buildings are fairly uniform, it becomes possible to consider the leakage loss as a function of the total window-glass surface, when deriving a general expression for the loss of heat from buildings of a given type, without introducing any considerable amount of error.

In reducing wall exposure to equivalent glass, a ratio of 4.5 to 1 has been taken as representing the relation which the heat-transmitting properties of glass bear to those of the materials of which the walls of the average building in New York City are constructed. Having made the foregoing assumptions, the following equation results:

$$T = \frac{\frac{W}{4.5} + G}{K} + \frac{G}{K'}$$

where

T = Tons of coal consumed per year for heating;

W = Total exposed wall surface in square feet;

G = Total window-glass surface in square feet;

K and K' = Constants for buildings of the same type and of similar form of construction.

As it is not necessary to solve the above equation, K and K' need not be separately determined. However, in order to provide a relation between the actual coal consumptions and the total glass equivalents of the buildings that were investigated, it was necessary to express K' in terms of K. For $K' = K$, the equation evidently becomes

$$T = \frac{\frac{W}{4.5} + 2G}{K}$$

The relation between K and K' can be varied considerably without affecting the result to any appreciable extent other than to alter the value of K.

Fig. 2 shows the results obtained by plotting the actual yearly coal consumption of some eighteen office and loft buildings located in New York City, against the total glass equivalents of these buildings, as represented by the numerator of the quantity on the right-hand side of the equation given above. The coal consumed in these buildings was used for heating purposes only, as all light and power requirements are supplied by means of electrical energy purchased from the central station. The loft buildings that are included are not what are known as manufacturing lofts, but they are, for the most part, devoted solely to sales purposes. It will be observed that the value of K for this type of building is approximately 100, which is a very convenient figure for practical use. Pea coal was used in almost all of the buildings which appear on this chart, but data were secured on a number of buildings where the buckwheat coals, or various mixtures, were being used. All such cases—as would naturally be expected from the somewhat lower average calorific value of such fuels—fall above the average of the buildings using pea coal, but in some cases to a considerably greater extent than can readily be explained by the difference in the thermal values of the fuels.

In examining the chart shown in Fig. 2, it may be observed that only four of the buildings show any appreciable amount of divergence from the mean, as represented by $K = 100$. The divergence of these four cases can be readily explained. One of those falling below the line was due to a considerable portion of the building being vacant and only being partially heated; the other is a building where a considerable amount of heat results from the industrial use to which a portion of the building is devoted. The two cases above the line are due, respectively, to poor building construction and to inefficient operation of the heating plant.

The foregoing explanation of the methods that were followed in deriving the equation upon which this chart is based, will make it evident that this equation cannot be employed with any high degree of accuracy in the case of any building that is so peculiar in its construction as to widely differentiate it from others of its class; also where mechanical ventilation is to be employed, a certain allowance must be made for the loss of heat arising from this source, over and above that which the equation provides for in the form of natural ventilation due to air leakage. However, as a means of arriving at the amount of coal required to heat a given building, the writer has found this method to be of considerable value, and, owing to the many uncertainties that are invariably present in any heating problem, the use of this method will probably lead to results quite as accurate, in the average case, as those secured by the use of a much more involved and elaborate method of calculation.

A method of estimating the amount of coal required to heat a given building, as employed by a Chicago company that is engaged in the business of operating steam-heating plants, will be briefly outlined. This company has derived a formula based upon a heating season extending from October 1 to May 1, a total of 243 days, or 5832 hours. The average outside temperature during this period being 36 degrees Fahrenheit, the average difference between this mean outside temperature and an inside temperature of 70 degrees Fahrenheit, is 34 degrees. The amount of heat lost by transmission per square foot of glass per hour per degree difference in temperature is taken as 2 B.t.u., which is twice the amount usually allowed for this loss. The loss of heat by transmission through ordinary brick or tile wall is taken as one-tenth of the loss through glass, or 0.2 B.t.u. per hour per square foot per degree difference in temperature. Taking the number of heat units in a pound of steam as 1000, the following equation is obtained:

$$C = \frac{S \times 2 \times 34 \times 5832}{1000 \times e \times 2000} = \frac{S \times 0.2}{e}$$

(approximately)

where

S = Glass surface, plus one-tenth the wall surface (north and west exposures being increased 10 per cent.);

e = Number of pounds of water evaporated per pound of coal;

C = Tons of coal required for heating.

It will be observed that S in the above equation is equivalent to $\frac{W}{10} + G$, which may be written in the form $\frac{1}{2}\left(\frac{W}{5} + 2G\right)$. In this latter form the quantity within the parentheses is practically identical with the quantity representing the total glass equivalent as given previously in the equation developed by the writer. The quantity $S \times 2$ in the Chicago equation is, therefore, practically equivalent to the quantity $\frac{W}{4.5} + 2G$ in the writer's equation. In other words, the leakage loss in Chicago has been provided for by doubling the glass-transmission factor.

In Fig. 2 the number of tons of coal required for heating have been plotted against the quantity $\frac{W}{4.5} + 2G$ (which is practically equivalent to the quantity $S \times 2$ of the Chicago equation) for a number of commercial buildings located in Chicago, and it will be observed that these buildings fall fairly closely along a line for which the value of K is 50. In other words, the amount of coal required to heat a building with a given total exposure expressed in terms of equivalent glass, is apparently twice as great under Chicago conditions as under those existing in New York City, the value of K for buildings of a similar type located in the latter city having been found to be approximately 100. The question naturally arises, how is this observed difference to be reconciled with the apparent difference in the heating requirements of the two cities, as shown in Table 1? From this table it would appear that the heating requirements in Chicago are approximately 19 per cent. in excess of those existing in New York City, while the actual coal requirements are practically 100 per cent. greater in the former city than in the latter. This apparent discrepancy can undoubtedly be explained by taking two additional factors into consideration—one of which has a very material bearing upon the heat loss of a building with a given exposure, while the other has an important bearing upon the amount of coal required to offset a given loss of heat. The first of these factors is that of wind velocity; the second is that of evaporation, or the average number of pounds of water evaporated into steam per pound of coal.

The average velocity of the wind during the heating season in Chicago is a little over 18 miles per hour, while the average wind velocity in New York City during the months when heating is required is approximately 13 miles per hour. As the wind pressure varies approximately as the square of the wind velocity, the mean wind pressure during the heating season in Chicago is approximately twice that existing in New York City. Now the loss of heat by air leakage is naturally a function of the mean external air pressure that results from the velocity of the wind. Therefore, in order to show the effect which the higher average velocity of the wind in Chicago has upon the heating requirements of the buildings in that city, as compared with those of similar buildings in New York City where the average wind velocity is considerably lower, it is only necessary to estimate approximately the average relation of the heat loss due to leakage to the total heat loss under New York City conditions. In the latter city it has been found that the square feet of window surface of office and loft buildings averages about 20 per cent. of the total exposed wall and glass surface; hence, by referring to the expression for the total heat loss, $\frac{W}{4.5} + 2G$, it will be seen that the average heat loss from leakage, under New York City conditions, is approximately 35 per cent. of the total heat loss. Based upon the increased air leakage alone, the Chicago heating requirements are therefore 135 per cent. of those existing in New York City.

From tests made upon a vast number of Illinois coals by the United States Geological Survey, it would appear that a figure of 11,000 B.t.u. per pound may be taken as representing the average heat content of these coals as fired. Pea coal, such as is used in the majority of New York City buildings, will probably average something over 12,000 B.t.u. per pound. Consequently, if these different kinds of coal were burned with equal efficiency, the amount of Illinois coal required would be about 110 per cent. of the amount of pea coal necessary to supply an equal quantity of heat. It is very probable, however, that the actual ratio is more nearly expressed by 125 per cent., due to the fact that pea coal, when used in the average heating plant, will unquestionably show a considerably higher efficiency than that shown by such grades of soft coal as are commonly used in the heating plants of Chicago. Hence, if this contention and the foregoing assumptions are correct, we have an explanation of the fact that the amount of coal required in Chicago for heating a given building is twice what it would be were the building located in New York City; for

$$1.19 \times 1.35 \times 1.25 = 2$$

The heating requirements of a large number of Boston buildings have received careful investigation at the hands of Davis S. Boyden, of the Edison Electric Illuminating Company, of Boston, and as a result of these investigations he has developed a somewhat complicated formula for use in determining the amount of coal required to heat a given building. As the accuracy of this formula depends very largely upon what values are assigned to a number of variables, its use is necessarily confined to these who possess more than an ordinary knowledge of the subject of heating and who are capable of using a considerable amount of judgment in assigning proper values to these variables for any particular case.

In deriving this formula, the assumption is first made that 1 B.t.u. will raise 55 cubic feet of air 1 degree Fahrenheit, from which it follows that the heat units lost from a building per hour per degree difference in temperature will be

$$\frac{\text{Volume of air} \times \text{air changes per hour}}{55}$$

As it is usually impractical to estimate the amount of air displaced by partitions, floors, interior furnishings, etc., the term "volume of air" in the above expression is taken as the gross volume of the building less 10 per cent. The above expression then becomes

$$\frac{90\% \text{ of gross vol.} \times \text{air changes per hr.}}{55}$$

or

$$\frac{\text{Gross volume} \times \text{air changes per hour}}{60}$$

The next step consists of selecting the heat-transmission factors for glass and the materials of which building walls are usually composed. The loss of heat through a square foot of ordinary window glass per hour per degree difference in temperature is taken as 1 B.t.u., and the corresponding losses through brick and granite walls of the usual thicknesses are taken as 0.2 and 0.3 B.t.u. respectively. By thus providing for the loss of heat due to transmission, an expression is obtained for the total heat units lost per hour per degree difference in temperature. This expression is

$$\frac{\text{Gross vol.} \times \text{air changes per hour}}{60} + \text{sq.ft. of glass} + 0.2 \times \text{sq.ft. of wall}$$

Instead of next proceeding to make an assumption as to the average difference in temperature between the outside and the inside air, which, together with an assumed number of hours during which heating occurs, would result in an expression for the total heat loss in B.t.u. during the heating season, the expression in the above form was applied to what was considered to be an average building that was satisfactorily heated and had neither too much nor too little radiating surface installed. This resulted in a factor which is considered as being constant for any given locality, the value for Boston being 5.4. This factor represents numerically the number of B.t.u. lost per hour per degree difference in temperature between the outside and the inside air for each square foot of radiating surface. Consequently, when the expression given above is divided by this factor, the quotient will represent the proper amount of radiating surface in square feet for any given building. This radiating surface is then divided by 130, which is considered to be the average amount of radiation that can be supplied by one boiler horsepower throughout the heating season under the conditions existing in Boston, and the quotient thus obtained represents the average boiler horsepower required during the heating season. The final equation, in its general form, is as follows:

$$\text{Tons of coal per year} = \frac{\frac{V \times a}{60} + C_1 \times G + C_2 \times W}{C_3 \times (130 - T)} \times L \times d \times h \times \frac{34.5}{e \times 2000}$$

in which

V = Gross volume of the building, including basement if heated;

G = Square feet of glass surface, 10 per cent. being added for north and west exposures;

W = Square feet of wall surface, 10 per cent. being added for north and west exposures;

a = Average air changes per hour during heating period;

C_1 = Constant for glass = 1 for single glass;

C_2 = Constant for wall, usually 0.2 for brick and 0.3 for stone;

C_3 = Constant for local conditions = 5.4 for Boston;

T = Factor dependent upon relation the heating plant bears to the premises heated;

L = Factor for portion of building not heated, or for building not heated to 70 degrees Fahrenheit;

e = Average evaporation in pounds of steam per pound of coal;

d = Number of heating days during season;

h = Average number of hours of heating per day.

The values of h for different classes of buildings are given as follows:

Hotels, 15 to 16 hours.
Apartment houses, 12 to 14 hours.
Department stores, 10 to 12 hours.
Office buildings, 10 to 12 hours.
Theaters, 6 to 10 hours.

In the writer's opinion this formula is altogether too complicated for ordinary practical use. As previously mentioned, its accuracy, in any particular case, depends upon the value assigned to each of the several variables. A slight error in each of these assigned values might, by a cumulative action, lead to a total error of considerable magnitude. Moreover, the method employed in obtaining the so called constant C_3 (= 5.4 for Boston) introduces a considerable element of uncertainty, inasmuch as it would, conceivably, be an extremely difficult fact to determine absolutely whether a certain building had exactly the proper amount of radiating surface for its heating requirements.

While there are a number of other methods employed for estimating the heating requirements of a given building, they are all, of necessity, based upon the same general principles as those which have determined the methods described above, and they therefore differ from the methods described only in the manner in which they deal with the variables of which any heating formula is necessarily composed.

Continuous vs. Intermittent Heating

In reply to me in the Dec. 5 number of POWER, Mr. Evans chooses a building that is heated altogether by direct radiation while the original question was in regard to school buildings where an abundance of air is supplied for ventilation. In the report quoted it is correctly stated that when the building cools off, the radiation to the outside diminishes. Therefore, in intermittent heating, less heat is required, and, if there is any saving by continuous heating, it is because by this method the boilers are operated more economically. Mr. Powell's report then should not assume that at all times exactly 8500 heat units are obtained from a pound of coal because that would be the same economy at all times.

I contend that, in a school building which is fan ventilated, there is considerable saving in allowing the building to cool for a number of hours. In such a building, consider the heat to be divided into two parts, that necessary to heat the air for ventilation to 70 deg., and that radiated through the walls of the building. The first part, when school is not in session, can nearly always be dispensed with. This part is nearly always half of the total and often more than half. So that if the boilers are operated at the same rate of steaming, and therefore at the same efficiency, when school is not in session as when it is; there is enough heat to cause the temperature to rise rapidly.

There are so many things that enter into the consideration, that one has to be very careful in drawing conclusions from such tests as Mr. Powell made. For instance, it is a long way from correct to assume that the coal consumption for the 13 hours of the night is $\frac{13}{24}$ of the total consumption for 24 hours. To keep the factory at 70 deg. during the night would take more coal per hour than during the day, unless doors are opened very often in the day time. The night temperature is not only lower, but in the day time considerable radiated heat direct from the sun enters the building. If Mr. Powell would assume that it took a small per cent. more heat to maintain the building at 70 deg. during the night than in the day time, his figures would come out in favor of intermittent heating. But it is for the fan-heated school building with its comparatively short sessions that I claim the most saving.

H. H. HASTINGS.

St. Louis, Mo.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROBT McKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 28,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

One-Man Shifts in Power Plants

It is not uncommon in small plants to find one man performing the duties of both engineer and fireman, and in some large plants this is the practice on the night shift when a very small load is being carried. Where oil is burned under the boilers, it is possible to extend this practice to still larger plants.

While a slight reduction in the labor item is thus made possible, the wisdom of such a course is questionable. For, after all, the wages of an extra attendant (he need not be a high-priced man) are small when compared with the total power cost, and, viewed from the standpoint of providing additional protection, the increase in wages may be considered as cheap insurance.

Two men are required in the cabs of all locomotives and likewise in the pilothouses of ferryboats, this being considered a necessary precaution against accident should anything happen to the man at the throttle or the wheel. While in such event, more lives would be endangered in the case of a public carrier, still the impending danger to life and property is present, to a lesser degree, perhaps, in the case of a power plant.

To cite an illustration, some time ago the assistant engineer of the Pasadena municipal electric-light plant, who stood the night watch alone, attending the oil burners in the boiler room as well as performing his engine-room duties, was presumably struck by the governor and fell into the flywheel pit. This apparently happened about 1 a.m., but as the oil burners and the pumps were regulated so nicely the plant kept on running, the flywheel grinding all the time into the thigh of the injured engineer.

Not until long after daylight was it noticed that something was wrong at the power house, as the street lights were still burning. Upon investigation, the engineer was found dead in the flywheel pit, and a medical examination indicated that he had died about 5 a.m.; in other words, for four hours he was literally being ground to death. This fatality might have been averted had there been a second man on duty at the plant.

Viewing this incident from another standpoint, had anything gone wrong with the boilers or any of the machines while running without attendance, immeasurable damage might have been wrought to property and perhaps other lives endangered.

The whole question resolves into a compromise between economy and safety. If economy, in the long run, be considered as dependent upon safety, as we believe it should, then it would seem advisable, wherever possible, to have more than one man on a shift.

Steam Boiler Operation

Fuel, whether solid, liquid or gaseous, is burned most economically when just air enough to furnish the required oxygen for complete combustion is admitted to the furnace. If too much air is used, the products of combustion are chilled to just the extent that the heat which should be transmitted to the water in the boiler is used to heat the surplus air. While the combustion may be perfect with an excess of air passing through or around the burning fuel, about one-quarter of a heat unit will be used for each degree that every pound of excess air is heated in its passage through the furnace to the chimney.

It makes no difference whether the extra air goes through or around the fuel or is drawn in through the boiler setting beyond the furnace, the effect is the same in kind if not in degree. The cold air absorbs heat that should go to make steam.

If too little air is furnished, the combustion will be incomplete and a large percentage of the fuel will pass off in the form of a combustible gas which cannot burn in the furnace because of an insufficient supply of oxygen.

In many coal-burning power plants the boiler efficiency is low from one or the other of these causes. Where the grate area is larger than is needed to gen-

erate the steam used, the draft is restricted by the damper and much of the fuel, instead of being burned, is distilled and passes off unconsumed.

If the grate is not completely covered with fuel or if there are cracks in the setting, cold air is drawn in, reducing the efficiency just in proportion as the gases are cooled.

Many oil-burning furnaces are disappointing in their operation for the same reason. The oil is well atomized and burns with a clear, smokeless flame because it is thoroughly intermixed with air in sufficient quantity to make the burning complete, but owing to the facts that the air inlet to the furnace is too large and that the damper is opened too much, so much unneeded air is admitted that the boiler falls far short of its expected performance.

In a pumping station where there was an excess of grate area, a damper regulator was installed for the purpose of keeping the steam pressure more nearly uniform. This saved the fireman numberless periodical trips across the boiler room to the base of the chimney where the damper lever was located. With hand regulation the steam pressure varied from five to ten pounds either side of the desired point. A part of the time the damper was open too much for the demand on the boilers, but during this period the fire burned rapidly, giving the best results so far as combustion was concerned. When the damper was connected to the regulator and the draft was controlled by the steam pressure the damper never opened enough to make a brisk fire, and the fuel consumption was increased about ten per cent.

This was corrected by reducing the grate area until the required coal consumption per square foot of grate was such that the damper was wide open most of the time.

With the reduced grate area the furnace conditions were so much improved that the coal consumption was reduced six per cent. below that required by hand regulation.

In a tar-burning furnace the evaporation per pound of fuel containing 17,000 heat units was twelve pounds of water while running with the ashpit doors wide open. These openings were gradually reduced until all of the air admitted to the furnace passed through an area of twenty-five square inches. At this point the evaporation was fifteen pounds of water per pound of fuel, and further reduction in the air supply caused smoke.

These incidents tend to show the lines to be followed in steam-boiler operation.

All air in excess of that needed for the burning of the fuel should be kept out of the furnace. The combustion should be as rapid as possible, consistent with the demands for steam, and the grate area and air inlets should be as nearly as possible adjusted to obtain these conditions.

Steam Piping

The sole object of a steam pipe is to convey steam from one point to another. This fact is sometimes lost sight of, with the result that at the last moment the pipe is put up, usually along a row of building columns regardless of distance or accessibility. The broad principles to be observed in order to enable a pipe line to perform maximum duty are that it shall take as direct a course as practicable between any two points, have bends of as large a radius as possible, slope toward a certain point to provide for drainage and shall be only large enough to take care of the steam at a fair velocity. Very often circumstances compel to be neglected the first two of these principles, but they should all be considered as a basis for the design of every pipe line.

Adherence to the first principle results in a minimum amount of material required, as well as a minimum amount of labor for erection and, consequently, a lower initial cost. Low costs for repairs and maintenance will follow, as will also minimum losses due to radiation, etc., all of which naturally tend to keep down the operating costs.

The second principle, namely, the use of long radius bends, gives the steam a less retarded and obstructed path so that the drop in pressure at the discharge point is not unduly great, and numerous joints, which are always points of weakness in a pipe line and frequently afford pockets in which condensation will accumulate, are eliminated.

The question of proper drainage is always an important one and should never be overlooked. The fruits of neglect in this particular are often a blown-out cylinder head or burst pipe, caused by a slug of water resulting from the accumulation of condensed steam. If, because of local conditions, it is impossible to install a line without low points, provision should always be made for drainage at these points. Water in a steam line usually indicates improper construction or neglect to see that the traps, etc., operate properly and is a condition that should not be permitted.

In laying out a steam line, error more often occurs on the side of extravagance than economy when the size of the pipe to be put in is considered. This part of a power plant is so costly in comparison with the rest of the equipment, especially when large valves are employed, that every effort should be made to minimize such cost as much as maximum efficiency will allow.

The question of radiation and its consequent losses should also be a potent factor toward this end for, naturally, the smaller the surface exposed to the surrounding air the less will be the cooling effect. Advocating small-diameter pipes and high velocities for steam is, to a certain extent, inconsistent with minimum pressure loss; therefore, a compromise should be effected between the loss of heat (assuming, of course, that the line is properly covered) and the loss of pressure.

Beyond a certain small loss of pressure, any increase in pipe diameter affords so little reduction in friction and adds so much to the heat-reduction losses that the tendency toward the smaller pipe and a greater steam velocity, within limits, is amply justified from the operating side as well as from that of first cost; therefore, the expenditure involved in the installation of a line really larger than necessary is in practically every instance out of all proportion to the small gain in pressure.

The Delray boilers, with their 23,654 sq.ft. of effective heating surface and over 400 sq.ft. of grate, are the largest stationary boilers in the world. An interesting comparison is the record-breaking locomotive just built for the Pennsylvania R.R. With 7723.6 sq.ft. of heating surface and 96 sq.ft. of grate this immense boiler on wheels will generate nearly as much steam as the stationary boiler at its normal rating.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Corrosion of Boiler Tubes in Nashville

As the contributor of an article in POWER for Oct. 24 on corrosion, my attention has been called to the corrosion of boiler tubes in Nashville, Tenn. A new boiler was started up in April and by September all of the tubes had become pitted and had to be replaced. Commenting on boiler troubles in general, the Nashville *Banner* of November 2 says: "Some of the new piping that has sprung leaks has been taken to the office of the city water-works department, and in each case it was seen that the pipes were rusted out in spots, and not uniformly, as they would have been if the rusting had been the result of the action of the water. The fact that the rusting was in spots showed that there were flaws in the iron at the places where the rust came. If the pipe had been good and the rusting had been the result of the water, the entire surface would have rusted, for it is obviously impossible for water to be selective in its action and touch certain spots while not touching others."

At first this might appear to be common sense, but a careful study as to why a tube rusts more at one place than at another has developed the fact that the rising air bubbles liberated from the water stick fast to the surface of the steel tube, especially at those places where a roughness already exists. Air and water act simultaneously on the iron and rusting begins. The air bubbles liberated by the further deäeration stick fast at the rusted places so formed which, compared to the other parts of the surface of the tube, become very rough, thus causing an increasing spreading and deepening until a complete rusting through occurs. This shows that even if the tube is rusted at one place more than at another, the fault is not that the metal is more liable to rust in one place than another, but simply that it happened to begin there.

The Nashville *Banner* quotes Dr. Hollingshead, of Vanderbilt University, as follows: "As to the boilers, I think that the trouble will be found to be due partly to the fact that the old mud incrustation on the tubes is being worn off, but far more is it due to the use of the modern steel tube. The old charcoal iron tubes are not now used and steel tubes are not homogeneous. There are places in them where particles of various substances are found, and water acts on these places, causing electrolysis and decomposition in those spots. Any water would do this."

Without going into the relative merits of wrought iron and steel tubing, one fact which may apply to boiler tubes is that conditions today are much more favorable to electrolysis and corrosion due to the presence of stray electric currents than they were years ago when the wrought-iron tube was in use, and this is not disputing the opinion that the wrought-iron tube rusts less than the steel.

Coming now to the practical question of how to make the boiler tubes actually supplied last as long as possible, I believe that with the softened water supplied in Nashville the boiler tubes could be given some protecting coating as cement or graphite. I am not a steam-boiler expert and my only reason for this opinion is obtained from the new book of Spalckhaver and Schneider on the steam boiler ("Die Dampfkessel") in which it is said that a large number of boiler paints are being brought into the market, and nearly all of them are advertised as a universal means of protection regardless of the character of the boiler feed water and, besides preventing the corrosion, are supposed to overcome the formation of boiler scale and consequently to add materially to the saving in fuel.

It is pointed out, however, that even when the paint actually has one or the other effect, still its use is not to be advised in most cases since a coat of paint can never be maintained over the entire surface without interruptions. At any interruption, however, the destruction of the boiler plate would proceed as before. The coat of paint would easily be injured, especially if during the operation pieces of the boiler scale spring off, since the paint usually sticks to the scale and not to the metal. By pure feed water the inner coating of paint would remain longer unharmed and prevent the corrosion if the rust-preventing paint was spread on after the metal has been cleaned by sand blast. The preliminary cleaning of the wall is of especial importance since otherwise the corrosion would proceed underneath the coat of paint and by the increase in volume relative to the original condition occasioned thereby, the protecting coat would be lifted off, permitting the further entrance of the corroding agents.

Since the paints used are easily volatile and ignitable, their application on warm heating surface is not permissible for, under some circumstances, as by the use of open lamps, explosion of the gases formed may endanger the men engaged in painting. Oily and fatty substances are likewise not to be used as paints since they prevent the perfect contact between the water and the metal wall and, aided by the subsequent formation of boiler scale, can occasion the overheating of the metal wall or even buckling of the plates.

Cement has in many cases proved good as a paint for the inside; likewise graphite, if it is applied to the previously well-cleaned boiler plate and carefully rubbed on.

L. B. TAYLOR.

Toronto, Ont.

A Clutch That More Than Paid for Itself

Several years ago I was first assistant engineer in a textile plant having a pair of 22 and 40 by 72-inch tandem-compound Corliss engines turning 53 revolutions per minute with a direct-connected air pump and condenser. This outfit was known as unit No. 2. There was also an 18 and 36 by 48-inch single tandem compound Corliss engine turning 91 revolutions per minute with an independent air pump and condenser. This engine was unit No. 3. These units were side by side.

One day while everything apparently was running all right, one of the valve studs in the water end of the No. 3 air pump came out and the action of the water worked the stud into such a position that it caught lengthwise between the front cylinder head and the oncoming piston. The consequence was a break in the piston rod right next to the water piston. As unit No. 3 was operating at about 40 per cent. overload, it was out of the question to run it noncondensing and expect to carry all the load.

Inside the mill there was a friction clutch to couple the countershafts of the two units together in just such an emergency as this.

The clutch was thrown in and a wooden block was made to hold the governor of No. 3 in its highest position. Thus this

engine carried a maximum constant load and the No. 2 unit took care of the balance of the entire load and whatever slight variations occurred.

Although the clutch had never been used before, the saving that it effected by preventing a shutdown in this single instance amounted to many times the cost of its installation.

A. LAMARINE.

New Bedford, Mass.

Homemade Auxiliary Heater

In the plant where I am employed, there are two compound pumping engines of about 5,000,000 gallons combined capacity, four double return-tubular boilers, two air pumps and two duplex feed pumps, also two small flywheel air compressors. In fact, the equipment is supposedly in duplicate, but whoever designed it fell short on one of the most essential features, in that only one heater was provided for the entire plant, with not even an injector to be used as an auxiliary to tide over periods when the heater was being cleaned.

A short time ago, however, the man who had put the ban on any alterations or additions to the heater was relieved of authority and after the new superintendent had been on the job a short time, I was much surprised one day when he asked me if there was any auxiliary feedwater heater. I told him that there was none and that we did not even have an injector to use while washing out the heater.

"What provision do you think advisable?" said he.

"It will be necessary to do something at once," I replied, "for on examining the heater yesterday I found that all the piping inside of it was so badly pitted that the heater cannot perform its most essential duty, the filtration of the feed water." I suggested that an auxiliary heater be built and placed near the present one.

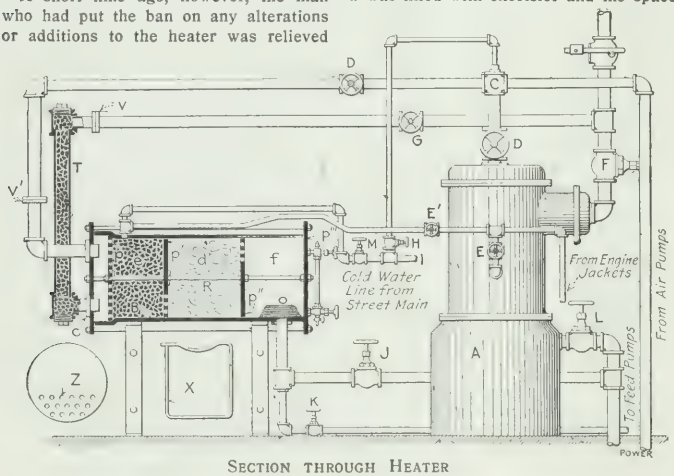
"All right, go ahead," said the superintendent.

The result is shown in the accompanying sketch.

The original vertical open heater is represented at *A* and at *B* is shown the new one, which was made of a piece of 30-inch cast-iron pipe. The ends were chipped smooth enough to take a gasket and then the four plates *p*, *p'*, *p''* and *p'''* were procured from a local boiler shop. The plate *p* was drilled full of ½-inch holes spaced about ½ inch apart; *p'* and *p''* were drilled as shown at *Z*, with the holes in *p'* at the bottom and those in *p''* at the top (these were drilled together in one operation). The rod *R* was run through the center of the three perforated plates, the nuts and keys holding the plates firmly in place.

Keys were used on the inside because threaded bolts soon corrode and also because it is impossible to turn a nut on them for any great distance, unless both the rod and the nut are of brass or copper.

In the space *f* was placed the galvanized-wire screen cover *O;* the space *d* was filled with excelsior and the space *e* with coke. There were no means at hand for making a baffle-plate oil separator; hence a piece of 8-inch wrought-iron pipe was attached, as shown at *T*, and filled with coke. This served to extract the oil, and by renewing the coke at each cleaning it gave very good results.



SECTION THROUGH HEATER

To remove the oil extractor it was necessary only to disconnect the flanges at *V* and *c*, and the coke could be removed or replaced by removing the plugs at either end of the pipe. The method of removing the front head and the perforated plates is obvious from the sketch. The plate *p''* is not removed unless for renewal. After the plates *p* and *p'* and the coke and excelsior have been removed, the hose is brought to play on the two filtering chambers, and then the filtering materials are renewed.

The two brackets which support the heater are shown in a side elevation at *X*. They are made of ⅜x3½-inch strap iron, with two 1-inch bolts extending through a 12-inch retaining wall.

The method of operating the heater is as follows: The water from the air pumps is forced through the line containing the cross *C* and is prevented from entering the vertical heater by the gate valve *D*. The exhaust from the auxiliaries is forced into the heater through the line containing the valve *G* and is prevented from entering the vertical heater by the valve *F*. The line containing the valve *E* is the steam-jacket drain line from the two engines, and is cut off from the vertical heater by the valve *E*. The line with valve *H* leading to the cross at *C* is the reserve supply, or cold-water line leading from the street mains, and the amount of water required is controlled by the valve at *M*. The valve *J* is in the line that supplies the water by gravity to the feed pump, and this is prevented from entering the vertical heater by the valve *L*. The valve at *K* is simply a drain to let the water out of the horizontal heater, and with the valve *J* closed and valve *K* open, all the mud and oil will find a way to the sewer without first dirtying the engine-room floor around the heater.

This heater has been working all right for three months, and the old heater is repaired and in good working order, but I do not use it simply because I believe in letting a good thing do the work while it will.

C. W. DUNLAP.

Depew, N. Y.

Sight Seeing in a City Factory

While on a visit to a certain large city, I was introduced to the superintendent of one of the factories there. He extended to me a cordial invitation to inspect his plant, which I gratefully accepted.

First, there was the office with large plate-glass windows, giving plenty of light, large clothes lockers for all of the office help, a large toilet room with white enameled wash basins, and combs, brushes, towels, soap, etc., all furnished by the company. There were two large fans for clearing the room of foul air. In short, everything possible was done to make the office force comfortable. The office employees worked only eight hours a day and received good wages.

We next went to the top floor where the articles of manufacture were given the finishing touches by the painters and packed for shipment. Here I found things a little different from the office, though very comfortable. There were eight painters and ten helpers or handymen, the painters receiving from $3 to $4 per day of eight hours, and the helpers from

$1.25 to $2. The paint shop and packing room had large windows on all sides, furnishing plenty of light and air. Each man had a small closet, just large enough for his coat and hat. There were three cast-iron wash sinks in the paint shop, each man furnishing his own soap and towel.

On the next floor was the carpenter and pattern shop. The carpenters were paid from $2.25 to $3.50 per day for nine hours; the pattern makers from $3 up to $5.50 for eight hours. Although their room had several large windows, the light and ventilation could have been improved at a small cost. On one side of the carpenter shop they had to use electric light on cloudy days. There was a large blank wall in which a window could have been cut, but the company would not go to the small expense. The foremen of the carpenter and the pattern shop each had a large clothes closet which they had built themselves from packing cases. The journeymen had no place to put their clothes except in their tool boxes and on nails driven in the wall. There were two sinks in the carpenter shop.

Next, we visited the machine shop, on the main floor. There I found men of half a dozen nationalities working 10 hours per day at wages ranging from $1.25 to $2.50 per day. The clothes lockers were a little larger than a bird cage. The men had to use pails (which they furnished themselves) to wash up, heating the water with a steam hose.

We then visited the foundry, where I found about the same class of men as in the machine shop. The wages were from $1.75 to $3.50 for nine hours. Their clothes were kept in a shed outside the foundry, and there was one dilapidated-looking sink in which to wash.

The superintendent then wanted to go back to the office, but I asked to see the engine and fire room. He said that it would be too hot for him, but I might go down if I thought I could stand the heat.

The engine room was about 18 or 20 feet below the level of the street. The thermometer stood at about 125 degrees, and not a window in the room; a small air shaft off at one end, with a fan belted from the engine, was the only means of ventilation. The fan was made and installed by the engineer.

Two Corliss engines direct-connected to generators furnished the power and the light for the factory, and there were two fire-tube boilers placed back under the sidewalk, with a grating for light and ventilation. The engineer had no place to hang his clothes, or to put packing, tools or anything else, and he had to use a pail to wash up. The floor was of rough, cheap cement made from one shovel of cement to seven of ashes, the top dressing being placed for two or three feet around each engine. The floor was put down by the engineer, who did the best he could with the materials at hand. He worked 12 to 13 hours a day, six days per week, and made his repairs, cleaned the boilers, etc., on Sunday. His wages were 20 cents per hour! There is quite a difference from the office to the engine room!

Is it just that an engineer, with so many lines depending on him, should be so poorly paid and so neglected even in the matter of necessities, let alone conveniences?

W. V. Ford.

Norwich, Conn.

Engine Needs Compression

Not more than 1000 miles from Boston is a paper mill containing two engines, one a double and the other a single machine, both running high pressure. The old chief engineer of this establishment boasts that he is running those units without compression, therefore making a great saving.

These engines are of well known makes, with piston rods held in a taper fit in the crossheads by two keys. About every two months the chief and the plant machinist, the latter receiving $6 for his day's work, put in one entire Sunday drilling and chipping out the keyways in the crossheads to allow for wider keys being inserted as the rods have pounded themselves loose in their sockets and the keys have been driven up to their heads. It is only a question of time when the slots will be so long that new crossheads will have to be ordered. In the shop there is a large pile of keys that have grown too small for the job.

To my way of thinking, if the chief would give the engines a little compression, the company would be the gainer in the long run.

Edward E. Moore.

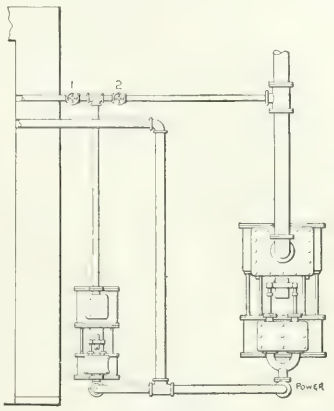
Atlantic, Mass.

Feed Pipe Arrangement

In a plant which consisted of a horizontal tubular boiler, a large duplex pump which discharged into a main leading to a standpipe, and an 8x6x6-in. duplex boiler-feed pump, the capacity of the feed pump was far greater than the evaporation of the boiler, and it was operated for but a few strokes and then shut down till the water level fell in the boiler.

This imposed an undue strain upon the boiler as well as the fireman, who had to force his fires previous to starting the feed pump, in order to prevent the falling of the steam pressure.

I overcame the difficulty by connecting the feed line to the main, as shown. By means of this arrangement the feed pump was run continuously, and the feed to the boiler was regulated by manipulating the valves 1 and 2. When both valves were open all of the discharge went into the main, since the pressure there was less than that of the boiler,



Plan of Piping

but by throttling with valve 2 the desired feed to the boiler could be obtained.

R. S. Martin.

Fort Worth, Texas.

On Keeping Record of Plant Performances

I should be glad to get the ideas of other Power readers on a systematic means for running various-sized installations.

It seems to me that the ideal way to run a plant is to be able at all times to determine just what each piece of apparatus is doing, and to do this I think that from time to time each piece ought to be calibrated according to a certain fixed standard, preferably based on what the apparatus did when new. Of course, a certain percentage of loss will have to be allowed for leakage, wear, etc.

In figuring the cost of light, heat, ventilation, etc., there is always the possibility of placing charges against these items which in reality belong somewhere else. To offset this I suggest a system whereby each engine, pump, etc., be first numbered, then rigged up for a test under actual working conditions and a careful note made of the data thus gained.

In these times of keen competition I think that engineers should take a greater interest, in their work than ever before, because as business competition grows keener so does competition in the engineering line by reason of greater facilities for learning. The uptodate engineer should be uptodate in reality when it comes to answering questions regarding each piece of apparatus under his care if it is at all possible to do so.

H. H. Burley.

Brooklyn, N. Y.

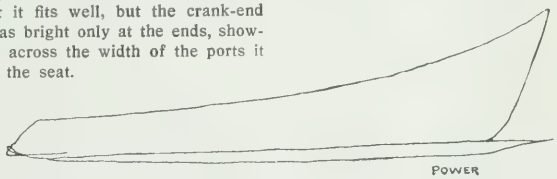
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Engine Runs with Steam Valves Closed

I have been much interested in the ntributions under this head as I have arge of a Corliss engine which will n when the steam valves are closed. ne accompanying diagram was taken nile the engine was running under these nditions at a speed of 10 r.p.m. The ngine has two eccentrics and it ex-usts into a heating system against a ck pressure of 15 lb. The diameter the cylinder is 24 in. and the stroke 42 in.

I removed both admission valves and und that the head-end one was true d bright the full distance across, show-g that it fits well, but the crank-end lve was bright only at the ends, show-g that across the width of the ports it as off the seat.



DIAGRAMS FROM ENGINE WITH ONE LEAKY STEAM VALVE

When the engine runs with the admis-on valve closed it slows up as it ap-roaches the crank end of the stroke d then speeds up on the return. From is it is easy to tell at which end the ak is located.

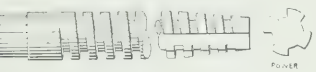
GEORGE TAYLOR.

Millinocket, Maine.

Wrought Iron Tap

The letter in POWER for Nov. 21 about n emergency reamer attracted my at-ntion and called to mind a job of the ays before machine steel became com-on.

An old wood-planer was being over-



WROUGHT-IRON SCREW WITH FLUTED END

auled. The elevating screws were worn ut and the threads in the crossrail were ripped. New screws were made of rought iron a little longer than the old nes, and the ends were fluted like a p and case-hardened.

The holes in the crossrail, which was f cast iron, were then tapped out with nese screws, and afterward the fluted ends were cut off from the screws. A first-class job was thus obtained.

JOHN A. COOK.

Birmingham, Ala.

Expert Advice

The editorial on page 788 in the Nov. 21 issue gives good advice when it says: "Advice which is valuable is worth paying for," but it should have gone a bit further and added, "but be sure that the advice is valuable before you engage it."

Usually, the engineer is capable of taking care of his plant in installing and operating new machinery, but sometimes a condition will arise in which he has had little or no experience; in this case the calling in of a consulting engineer (or expert advice) is a good investment, but care should be taken to get a man of good reputation and inquire into his previous work before engaging his services. The advice of a makeshift is dear at any price and if a machine is installed which is not suited to the duty it is to perform, it is a constant source of trouble and annoyance to the operating engineer.

I have had this experience and it still is a source of daily trouble.

We were contemplating the installing of an internal-combustion engine, generator and auxiliaries, and as our experience with this type was very limited, the firm engaged the services of a consulting engineer who came recommended as "the best in the state." After giving him all the data we could as to the duty the engine had to perform, etc., he left. In due time the specifications arrived and we advertised for bids. Plenty of engine builders wrote in for a copy of the specifications, but when the time came for letting the contract a very few builders were represented. They said that the specifications were so that but one company could build an engine to come up to the queer requirements. After some discussion the date for letting the contract was set a month later and new specifications were made out, with a slight change over the old ones, but still favoring this one firm of builders. We also gave a very flattering history of our plant, the town and its population.

When the contract was finally let this favored firm's bid was accepted, as the consulting engineer claimed it was the only engine which was fit for our service, although other bids gave a lower fuel consumption and a better operating guarantee.

The specifications stated that the engine should be in operation in 90 days after signing the contract; that if the contractor did not have the engine installed and operating in the specified time, he would have to pay $10 per day for every succeeding day the engine was not operating.

It was just five months later when the engine was finally started and the acceptance run was made. The fuel consumption was higher than the specifications called for, but the consulting engineer said that the fuel consumption called for in the specifications was too low and that the engine was doing well, better than he had expected. When asked about that $10 per day damages, the builders' representative pointed out that as there was to be no premium if they were ahead of the specified time, we could not hold them to this forfeit.

After this engine had been in service six months it proved to be too light for our service. It was under a constant strain all the time, the crankpin and crosshead-pin brasses wore far too fast and were subject to heating because of insufficient bearing surface; they needed keying up every day; the governor was unsatisfactory; in fact, the engine was not built for our service.

Later on, when I showed a copy of the specifications to a consulting engineer of high standing, he said they were so drawn up and worded that a coach and four could be driven through them.

About a year later we bought and installed another engine and generator, and with our previous experience we knew just what we wanted. Our superintendent took charge of this work and we got much better satisfaction than the time before.

This is no reflection on the consulting engineer in general, for we are at present employing one to install a water-filtering system, but before engaging his services we made careful inquiry as to

his ability for this kind of work and we wrote to the operating engineers of several plants where he had installed this type of filtering system, asking them what satisfaction his work and advice gave, and it looks as if we will get our money's worth this time.

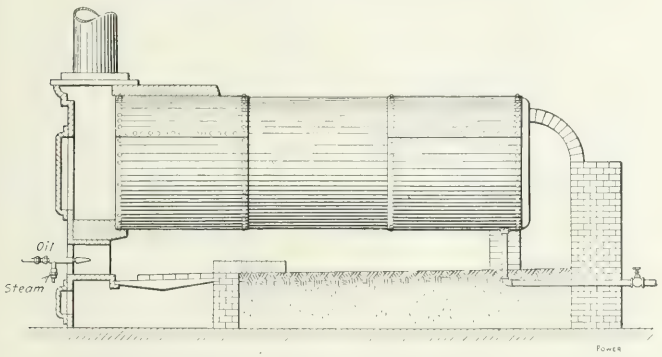
M. W. Utz.

Minster, Ohio.

Burning Fuel Oil

I noticed in a recent number that D. A. Steiner wished some information regarding a suitable design of furnace for burning fuel oil.

I have found the design shown in the accompanying figure to be quite satisfactory. Cover the entire grate surface with firebrick except for a space of 8 to 12 in. at the front, which should be left bare to admit air from the ashpit. Cut



Arrangement of Burner and Furnace

down the bridge-wall to the grate level and fill up the back combustion chamber as shown; have the filling take a slight slope up toward the rear. Protect the blowoff pipe well from the flame. Regulate the damper and ashpit doors according to requirements of load, etc.

John Weil.

Escondido, Calif.

Vibrations of the Indicator Pencil

Amos F. Moyer, in the Nov. 28 issue, while criticizing the writer's article under the above heading published on Oct. 31, attributes the undulations in the indicator diagram to the vibration of the spring rather than of the pencil arm. Mr. Moyer holds that the natural vibrations of the arm are too high.

In reply, the writer wishes to call attention to the fact that it requires two "beats" or oscillations to form a graphical wave, and, further, that the pencil arm is comparatively heavily loaded and supported in a complicated manner as well as loaded, and that a complete calculation of the vibration period would not show too high a frequency for the case in question.

The vibration period of the indicator spring, either free or loaded, is entirely too low for consideration. However, it is nearer the truth to say that both have their influence upon each other, and that all the reciprocating parts exert a modifying effect upon the wave form. Mr. Moyer's diagrams of Nov. 28 show this very clearly.

In reply to Charles F. Prescott's criticism of Dec. 5 on the grounds of economy, the writer offers the accompanying diagrams. These were taken from a 19½x21-in. four-valve engine in the shops of the Chicago & Northwestern Ry. at Lake Shore Junction, Wis. This engine is running at 200 r.p.m. under 110 lb. steam pressure. During a recent test of this engine by the writer and two engineers of the railroad, the following results were obtained:

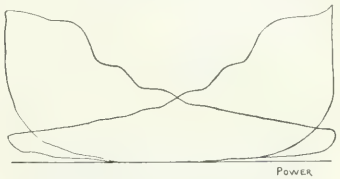
Load in percentage of rated load	Pounds of steam per i.hp.-hour
32.9	27.9
48.8	27.3
77.2	25.7
101.0	24.5
134.0	25.6

The steam used by the engine was passed through a surface condenser and weighed. The steam was also measured by a Gebhardt steam meter which gave a very satisfactory check on the weighed condensate. The economy speaks for itself, and it is good in spite of the jagged expansion line.

The writer has seen diagrams from English high-speed compound engines, with worse-appearing expansion lines than the one in question, developing an indicated horsepower-hour on 10.5 lb. of steam.

Mr. Prescott cites an experiment he made of soldering a strip of tin to the pencil arm, and because this did not remove the waves he claims the indicator is not responsible for them. It is not to be expected that this would remove the waves; it would, however, greatly alter them, as he may see by carefully looking over the diagrams presented. He holds that the sinuous expansion line is due to governor action; that is, unsuccessful attempts of it to close the valve. This would mean that the friction of the valve throws the weight arms through their entire range every quarter revolution, and does this by a succession of jerks, always steadying and returning to the exact position in time for cutoff No. 1.

Now, this is a very convenient governor for the hypothesis offered, but it would never control an engine. The shaft governor is powerful and no valve-gear can stand up while it receives such treatment. Were the governor blocked for a given point of cutoff, it would still show the same characteristic diagram. If these waves do actually represent an intermittent admission, why is it that the terminal pressure is as normal as though no reopening had occurred? The most vulnerable point of Mr. Prescott's hypothesis, however, is its narrow application; for numerous steam engines with widely differing types of valves and gov-



Diagrams from Engine Operated on 24.5 lb. of Steam per hp.-hr.

ernors, and various internal-combustion engines of both gas and oil, show similar waves in the expansion line.

No instrument made by human hands is perfect. They all have but a limited field and their peculiarities and shortcomings within that field. Every different make of indicator has its own individuality and characteristics which are also changing with age and wear. The engineer, by study and experience, must learn to recognize the fundamental facts from the hurried record; as the child, having learned the ideal letter forms, must learn further to recognize these same letters and words in the hasty manuscript of its elders.

J. W. Taylor.

Massillon, Ohio.

Central Station vs. Isolated Plant

I have been interested in the discussion of the above subject in Power as I have had some experience with the central-station solicitors.

I have lost one position to them and have been able to keep one contract from them. In the first case it was a brickyard plant running only in the summer months and shut down on rainy days. As the owners had no need for steam except to drive the engine, I could

not put up much of an argument against the central station. I know, however, that since changing over to the central-station service, as far as expenses are concerned, they just about break even with the cost of the old system.

The second case was that of a tenant on one of the floors of the building which my present plant serves. This man thought that he might reduce his expenses by buying outside current. He requires about 10 hp. to drive some shoe machinery. The central-station solicitor came in and looked over his machines and said that if they were all running all of the time it would take about 18 hp., but his average would not be over 10. He would let him have current at 3 cents per horsepower-hour and guarantee that it would not cost more than $30 per month.

As near as I could figure the same proposition, 3 cents per horsepower for a 10-hour day would be $3 per day, and with 26 working days in a month, it would be $78 per month.

It seems to be the same way everywhere. I have talked with engineers who know more about the business than I do, and all of them say that they cannot figure with the central station and understand it.

L. W. CHADWICK.

Bridgewater, Mass.

Using the Firm's Stationery

In the Nov. 28 issue, Mr. Utz gives his experience in using the firm's stationery. My experience has been that this oftentimes gives the letter too much of an air of responsibility. Some time ago, while reading the advertising section of POWER, I decided to try a sample of a certain well advertised grease which prior to that time I had never used; at the time the grease in use was not giving entire satisfaction. So I used the firm's stationery to request a free sample, together with a grease cup, and stated in the letter that the grease was to be sent to my private address and not to the company's.

In about a week the supply clerk told me that he had just received a package addressed to me in care of the firm. It proved to be my can of grease. I used it and found it to be just what I was looking for, but, although I recommended it to the purchasing agent, I could not get him to order a trial barrel at that time.

A few days later I received a letter from the grease company, inclosing a stamped envelope, asking for the results of my trial sample. I wrote them that it was a very good grade of grease and thought it would give much better results than the grease I was then using. This I considered a purely private affair as I had sent for the grease and tried it to satisfy my own curiosity as to its merits in my plant.

About two weeks later the superintendent received a letter from the grease company, inclosing a copy of my letter on the firm's letter-head and signed by myself, recommending the grease, and urged them to buy a barrel. The superintendent called me to his office and asked me to explain myself. I told him and still recommended the grease as the best I had ever used for that plant and urged him to buy a barrel. He thought he smelled graft from the grease company and called it an underhanded way to get the grease tried; he would not order it on any conditions. We used about three barrels a year and consequently the use of the firm's stationery lost the grease company a good customer.

The grease would have been used if its makers had not employed the means they did to get the attention of the firm. Since then in sending for samples I purposely leave out the firm's name but state that if the sample proves satisfactory to me under the conditions I wish to use it I will call the company's attention to it; if it is not satisfactory I do not care to have them bother the company about it and bring me into the matter.

Since I have stopped using the firm's stationery when sending for samples, etc., I have had no trouble. Of course, when prices, etc., are asked and it is the intention of the company to purchase, then the firm's stationery is used.

J. C. HAWKINS.

Hyattsville, Md.

Engineer's Reference Book

Reading of late in POWER of the method of compiling one's own reference book, I must say that I also passed through the over-enthusiastic state noted by Mr. Bailey in the issue of Nov. 21.

However, I do not regret it one moment, for it is one of the best ways possible to impress upon a beginner the importance of delving into the root of whatever the subject at hand may be.

In the first place, it is usually something along his line of work, and important that he should know it, for it is understood such a reference book pertains only to his line of work, thorough in all its phases.

Too many times the compilers of these home-made reference books copy only the mechanical, electrical, hydraulic and allied topics, forgetting that the insertion of business methods is equally important. It is not a difficult task to figure how to work overtime, plus Sundays and holidays, but to eliminate those extra hours as much as possible is an important factor.

The collecting of data of any nature is for our own personal betterment and advancement; therefore, why stop at the dynamical side of the subject? While a reference book does not mean a collection of these, but rather abbreviated forms, points relating to social, financial and ethical phases of it should not be omitted. If one inquires regarding any successful man's career he will find that he has not neglected the observance of any one of the above points.

My practice now is the same as outlined by Mr. Bailey—"Copy all of some article into my book, but not unless it is of great importance or something that cannot be found in the handbook. After all, the handbooks contain a good deal of reliable information and are hard to beat." POWER has of late been treating of the low wages of engineers, especially in proportion to their hours, and in particular with the "higher-ups" in the engine room. The reason for this is at once made manifest in this brief sentence: There is too much mechanical and not enough business engineering.

Many engineers simply get in a rut, though they are apparently unaware of it. In New York City, engineers can be had for from $18 to $20 per week, which condition is pretty general all over the country, and it includes engineers in fairly good-sized plants and smaller but more complicated plants.

A cold-storage engineer who held a first-class license in Illinois told me that he would not work at the operating end as there was "nothing in it," and that he could more than double his earnings in laying out and erecting refrigerating equipment. It is claimed that New York City alone has 1000 engineers following other lines of work, low wages plus central-station inroads being responsible for much of it.

Had many of these engineers studied other branches relating to their work—though, to many of them, at the time apparently foreign to it—they would still be following their natural bent in life and with greater success. Those who have done so are continuing their engineering work and receiving a salary in keeping with their responsibility.

SAMUEL BROUTHERS.

Springfield, Ohio.

Emergency Die Stock

Recently I saw a description in POWER of an emergency die stock. Here is one I made in about ten minutes. I bored a hole in the center of a 2x4-in. board, the same size as the pipe I wanted to thread. Then, I nailed some blocks on

A QUICKLY MADE DIE STOCK

to keep the die from turning. When I wanted to cut a smaller pipe I nailed a block on the back side and bored a hole in it the same size as the pipe I was to cut. I kept the pipe from turning with a pipe wrench, and cut the best thread I ever made.

F. W. BAIR.

Hancock, Mich.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Barometer Reading and Lift of Pump

On a mountain where the atmospheric pressure is 12 lb. per square inch, how high would the mercury stand in the barometer, and to what height would it be possible to raise water by a suction pump?

P. P.

The relation between the barometer reading and the air pressure in pounds per square inch may be expressed as

$$Barometer\ reading = \frac{atmospheric\ pressure}{0.4908}$$

Applying this to the present problem,

$$Barometer\ reading = \frac{12}{0.4908} =$$

$$24.43\ in.\ of\ mercury$$

A column of mercury 1 in. high will balance a column of water 1.133 ft. high. Therefore 24.43 in. of mercury will balance

$$24.43 \times 1.133 = 27.7\ ft.\ of\ water$$

This is the theoretical height to which water could be lifted by the suction pump if the valves did not leak and there was a perfect vacuum in the suction chamber. In practice, it is seldom possible to obtain over 85 to 90 per cent.; therefore, the probable lift in the present case would be from 23.5 to 25 ft.

Gate Valve between Relief Valve and Exhaust Header

The atmospheric exhaust of our engines and auxiliaries is piped to a common header, making it impossible to inspect or repair the relief valves without shutting down the plant. Would it be safe to install a gate-valve between the relief valves and the exhaust header?

R. S. K.

Putting in valves as suggested is not unsafe if proper precautions are taken against their being closed by some careless or unauthorized person. This can be done by removing the handwheels and locking them open.

Boiler Horsepower

How is the horsepower computed of a 5x18-ft. return-tubular boiler having forty-four 4-in. tubes?

F. J. R.

The heating surface of a horizontal return-tubular boiler is one-half the area of the shell, the area of all the tubes and the area of one head minus twice the area of one end of all the tubes. In this case, one-half the area of the shell is

$$\frac{5 \times 18 \times 3.14}{2} = 141.3$$

The internal area of forty-four 4-in. tubes 18 ft. long is

$$\frac{11.75 \times 216 \times 44}{144} = 775.5\ sq.ft.$$

The area of one head is

$$5 \times 5 \times 0.7854 = 19.63\ sq.ft.$$

Twice the area of the ends of all the tubes is

$$\frac{12.56 \times 88}{144} = 7.68\ sq.ft.$$

$$19.63 - 7.68 = 11.95\ sq.ft.$$

Adding these together gives the total heating surface of the boiler.

$$141.3 + 777.5 + 11.95 = 930.75\ sq.ft.$$

Allowing 10 sq.ft. of heating surface per boiler horsepower, the horsepower of the boiler will be

$$\frac{930.75}{10} = 93.07\ hp.$$

Horsepower Constant

What is the rule for finding the horsepower constant of an engine? Give an example.

A. A. B.

To find the horsepower of an engine from a number of diagrams it is convenient to figure the horsepower developed per pound of mean effective pressure, and multiply this result, which is the horsepower constant, by the mean effective pressure of each diagram to find the horsepower developed from that diagram. This can be done by considering the mean effective pressure in the formula as 1 lb. As it is unity it may be left out.

The formula is as follows:

Multiply the area of the cylinder by the stroke in feet and the number of strokes per minute; divide this product by 33,000. The quotient is the horsepower per pound of mean effective pressure, or

$$\frac{ANS}{33{,}000} = hp.\ per\ lb.\ m.e.p.$$

This horsepower constant multiplied by the mean effective pressure is the horsepower developed.

Assume an engine 22x48 in. running at 70 revolutions per minute. The mean effective pressure obtained from one indicator diagram averaged 37 lb.; from another diagram the average pressure was 32 pounds.

The area of the cylinder is

$$22 \times 22 \times 0.7854 = 380.13\ sq.in.$$

The piston speed is

$$2 \times 48\ in. = 96\ in. = 8\ ft.$$

$$8 \times 70 = 560\ ft.$$

$$\frac{380.13 \times 560}{33{,}000} = 6.45\ hp.\ per\ lb.\ m.e.p.$$

Multiply the average unbalanced pressure of the first diagram by 6.45.

$$37 \times 6.45 = 238.65\ hp.$$

From the pressure obtained from the second diagram the horsepower developed would be

$$32 \times 6.45 = 206.4\ hp.$$

Pressure on the Guides

What is the maximum pressure on the guides of a slide-valve engine when the initial pressure is 90 lb. per square inch?

A. F. D.

Multiply the area of the piston in square inches by the pressure per square inch when the crank is at right angles with the guides. The product will be the horizontal push on the crosshead at this point. Divide the length of the connecting-rod by the length of the crank, and subtract 1 from the square of the quotient. Divide the horizontal thrust found as above by the square root of the remainder. The quotient will be the maximum thrust at right angles to the guides due to the steam pressure.

Assume an engine having a cylinder diameter of 12 in., a stroke of 14 in. and a connecting-rod 35 in. long. Applying the dimensions to the rule it may be thus expressed:

$$(12 \times 12 \times 0.7854) \times 90 = 10{,}179\ lb.$$

The horizontal push on the crosshead at this point is

$$\left(\frac{35}{7}\right)^2 - 1 = 24$$

$$\frac{10{,}179}{\sqrt{24}} = 2077\ lb.$$

the maximum thrust at right angles to the guides at 90 lb. initial pressure.

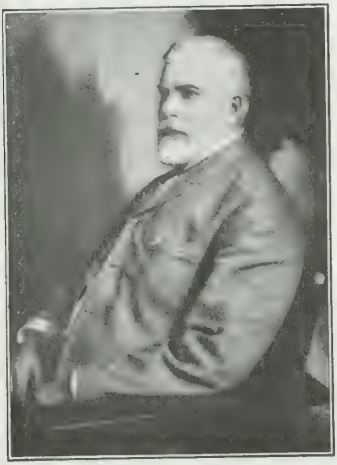
The largest electrical show in the world will be held in Boston in September. The Mechanics building, which will contain it, seats over 100,000 people at one time, and has 105,000 square feet of exhibit space.

OBITUARY

James McBrier, president of the Ball Engine Works, and a prominent business man, died at his home in Erie, Penn., on Jan. 4, at the age of 78. Mr. McBrier was born in Allegheny and received his early education in the common schools. In 1887, in company with several other business men, Mr. McBrier organized the Ball Engine Works, of which he was elected president, retaining that position until his death.

Richard Teller Crane, founder and head of the Crane Co., died at his Chicago home on Jan. 8.

Mr. Crane was born in Paterson, N. J., on May 15, 1832. The family being too poor to give the children much of an education, Richard started to work when nine years of age and after six years he found employment in John Benson's brass shop in Brooklyn in 1847. Four years later he entered the machine shop



RICHARD T. CRANE

of the Taylor Printing-Press Works, and later that of Hoe & Co., where he learned the machinist's trade.

In 1855, he went to Chicago and after obtaining advice and material assistance from his uncle, Martin Ryerson, he built a small brass shop on the corner of Lake and Market Sts.

Mr. Crane's policy from the first was to put his earnings back into the business, and he had sufficient courage to extend the business as rapidly as his means permitted. As a result, the business grew rapidly and steadily.

Some of the special lines in which Mr. Crane actively engaged were the manufacture and installation of elevator equipment, piping, valves, fittings and air-brakes. Elevators were made by the Crane Co. as early as 1867, and this business grew so rapidly that it was soon crowding other work out of the machine shop. In 1886 the elevator part of the business was separately incorporated as the Crane Elevator Co., and with a view to concentrating on the valve and fitting business the Crane Elevator Co. was sold in 1895.

Mr. Crane always took a lively interest in the welfare of his employees. Prior to the establishment of a pension system by the Crane Co., he personally pensioned employees whom sickness or old age overtook before they could lay by a competence. Through the Crane Co. in 1900, Mr. Crane gave to each employee 5 per cent. of the total amount of the employee's earnings during the previous year as a New Year's present. This had been his practice each year since, except that for the last eight years the amount was 10 instead of 5 per cent.

Mr. Crane took an active interest in social, economic, political and educational affairs and was prominently identified with many important movements. He was a student of and writer on educational problems. In all of his writings he placed great emphasis upon the distinction between an educational system adapted to meet the wants of the masses and a system suitable for training only a favored few. He laid especial stress upon the importance and practical value of manual training in the grade schools. In recognition of Mr. Crane's interest in the public-school system the Chicago board of education a few years ago named a new school the R. T. Crane Manual Training High School.

Indicted for Neglect

On Jan. 2, Francis S. Ward, commissioner of public works, at Buffalo, N. Y., and his chief assistant, Henry L. Lyon, were indicted on a charge of manslaughter in the third degree.

It is charged that their negligence in the preparation of plans for the city's power-plant building, which collapsed last June, caused the death of eight workmen.

Instruction in Heating and Ventilation

The evening school of the Harlem Young Men's Christian Association, 5 West One Hundred and Twenty-fifth St., New York City, opened an evening class in heating and ventilating on Wednesday evening, Jan. 10. This is the third season for this course. The instruction is provided especially for engineers, draftsmen, mechanics and salesmen of heating appliances. The course will consist of lectures, demonstrations of systems and appliances, visits to institutions for inspecting the operation of various heating and ventilating devices, discussions and answering pertinent questions.

Classes meet on Wednesday evenings each week, from 7:45 to 9:45. The course will extend over two terms of 11 weeks each. Membership in some branch of the Young Men's Christian Association is a preliminary requirement. C. A. Fuller, heating and ventilating engineer, is instructor.

SOCIETY NOTES

The Minnesota Electrical Association will hold its next convention in Minneapolis on Mar. 20 to 22. The Northwestern electrical show will be in progress at the same time.

The twenty-fourth annual convention of the American Boiler Manufacturers Association, together with its associate members and the Supplymen's Association, will be held in New Orleans, La., Mar. 12 to 15, at which time some very important papers will be presented to the association, and other business of interest to all the boiler manufacturers in the United States and Canada and supply houses dealing with the boiler and tank industry. An extensive program of entertainment has been arranged, and a large attendance of boiler manufacturers and supplymen from the United States and Canada is expected. Further information can be had by applying to F. B. Slocum, secretary, Supplymen's Association, of the American Boiler Manufacturers Association, the Continental Iron Works, Brooklyn, N. Y.

PERSONAL

George J. Henry, Jr., until recently chief engineer of the Pelton Waterwheel Co., San Francisco, Calif., has resigned in order to establish his own office in that city as a hydraulic and mechanical engineer with the idea of engaging in the manufacture of tangential waterwheels, turbines and power-plant specialties.

J. H. Ehlers, of Libby, Mont., in charge of mining and water-power development work at Yakt Falls, contemplates the building of an electric railroad in the Yakt Basin and the use of modern electric logging and manufacturing appliances in utilizing the immense stands of timber in that locality. It is expected to develop 3400 hp. at the falls, which will also be used in the operation of the mines at Sylvanite.

BOOKS RECEIVED

POWER-HOUSE DESIGN. By John F. C. Snell. Longmans, Green & Co., New York. Cloth; 448 pages, 5½x9 in.; 181 illustrations; plates; tables. Price, $6.

MODERN AMERICAN TELEPHONY. By Arthur B. Smith. Frederick J. Drake & Co., Chicago, Ill. Leather; 790 pages; 4x7 in.; 470 illustrations

POWER

Vol. 35 NEW YORK, JANUARY 23, 1912 No. 4

IT does not take an especially educated or experienced man to operate a small power plant so long as everything goes right. He may not operate it intelligently, and there is no question but that he will be wasteful of coal and supplies and that the equipment, no matter what condition it happened to be in when he assumed his duties, will suffer from his carelessness and ignorance. In many small plants and in some large ones the operating engineer may run things to suit himself so long as he is lucky enough to avoid accidents and succeeds in giving fairly reliable service.

If something goes wrong, the remedy which he applies is not likely to be the correct one. The engineer who started up and threw a load on a newly installed unit before the bedplate of the generator had been properly grouted to the foundation, did not realize that the magnetic forces were so unstable that they would soon cause the generator to move on the foundation.

His first intimation that something was wrong was when his hearing and his sense of smell told him that the coils of the rotor were rubbing against those of the stator. Not realizing the cause of the trouble, he used a strong but ill-advised remedy: He shifted the outboard bearing by means of setscrews provided for purposes of alignment until the rubbing ceased, but soon the trouble reappeared and he shifted the bearing a second time. The main shaft being forced out of alignment by this procedure, the crankpin box and the eccentrics soon began to heat and he was forced to shut down after the load had been transferred to the old machines.

Luckily, this man had not done any great harm, but every move he made displayed poor judgment and ignorance. His acts were based on guesses, not on good judgment backed up by knowledge. Such a man does not deserve the trust of operating a power plant.

When the competent engineer steps into his engine or boiler room, he is keenly aware of all that is taking place. He does not appear to be different from the ordinary mortal, but his perceptions and intellect are trained to detect irregularities; he is acquainted with the weaknesses of his apparatus as well as its strength; he knows the peculiarities of the load variations; he is able to burn the coal and convert heat energy into mechanical or electrical energy economically because he knows the "why" of the combustion of coal. In an emergency, his judgment is based not upon guesses and impulses but upon knowledge and experience. This makes him both resourceful and courageous.

The average owner of the small plant is accustomed to think that ordinary intelligence only is required to operate the equipment. It is as simple as boiling water in a kettle, so he thinks. Why, he himself could do all that is necessary to get up steam and start the engine in a pinch! This idea is so prevalent that owners are protected from their own judgment of the qualities of employees by a state engineer's and fireman's license law. These laws may only insure that the candidate has the average qualifications necessary to perform his duties. The employer must be made to realize that it is poor economy to hire an inexperienced man, even though it may be possible to purchase his services for less money.

The rank and file of operating engineers must also come to realize that ignorance and incompetence are not only personal defects, but also constitute an offense against their brotherhood.

Knowledge and experience open the road to results and results mean success. Knowledge, then, should be the aim of every operator. The experienced man, as well as the beginner, should constantly endeavor to progress.

The means of knowledge are close at hand. Given an inquiring mind and an ambition to use it, a few good books and engineering journals will furnish the means for great advancement. Standards will be raised and operators will have accomplished their own betterment.

Measurement of Hot Feed Water

By J. A. Knesche

The various types of instruments for measuring feed water are described. These include the venturi meter, the Pitot tube, volume determinators and weight determinators.

The suitability of each type for meeting certain conditions is also discussed.

In the power plants of industrial establishments a correct steam distribution is imperative, as competition is making it more and more necessary to know exactly and in detail the accurate charges which are to be made against the finished product. Furthermore, the cost of producing steam is now receiving more attention than formerly. Time was when the total amount of steam generated by a boiler plant was estimated from the quantity of fuel consumed. This method would be perhaps accurate enough if the efficiencies of the separate boilers were known at all times during normal operations and if the demand for steam were constant. But in many industrial plants the demand for steam is not constant. Moreover, the efficiencies of boilers do not remain the same, owing to the accumulation of scale in the tubes, etc. In determining the steam generated the feed water entering the boilers is usually measured, but when steam coming from one boiler is used by several engines and for heating and drying systems, the steam itself has to be measured.

Measurement of Hot Feed Water

Not every type of water meter is suitable to measure hot boiler-feed water. Many meters, notably those of the piston and of the disk types, will measure water correctly within 2 or 3 per cent. as long as the temperature is not over 100 degrees Fahrenheit.

One objection to measuring the water before it enters the boilers is that not all the water thus measured is converted into steam. In the normal operations of a boiler there is always a loss of feed water or steam the exact amount of which can seldom be determined. It might be argued that the quantity of water is always known before it enters the boilers during boiler trials where it is necessary to eliminate all feed-water and steam losses in order that the exact quantity of water evaporated may be known; but it should be remembered that in a boiler room the average operating conditions are very different from the conditions prevailing during a boiler trial. The water and steam losses are usually occasioned by leaks in the lines, valves or connections, while "blowing down" or by losses through the safety valves; all told, they may amount to 5 per cent. or more of the steam generated. These losses must be considered in the distribution of the steam generated in the plant.

Feed-water measuring devices may be divided into velocity, volume and weight meters. These different appliances, in order to serve the practical needs of the boiler room, must be fitted with either integrating, indicating or recording mechanisms, and in some cases with two or three of these.

Velocity Meters

The venturi meter consists of the venturi tube proper and the register connected by pressure pipes, the general arrangement being shown in Fig. 1. The water to be measured flows through the tube but not through the register, and since the tube contains no mechanism whatever, there can be no derangement of the meter tube proper due to solid particles carried along by the water. The tube is merely a pipe which tapers from each end toward the throat, which is usually lined with bronze and has a diameter of from one-third to one-half that of the ends of the meter; the total length of the tube is from eight to twelve times the end diameter. Near the inlet or upstream end and also at the throat are annular pressure chambers encircling the tube, communicating with the interior by numerous small vent holes. The cones of the tubes are usually made of cast iron, though in very large sizes they are sometimes made of plate steel, wood or even masonry. For metering liquids which will corrode iron, the tube can be made entirely of bronze or other composition metal.

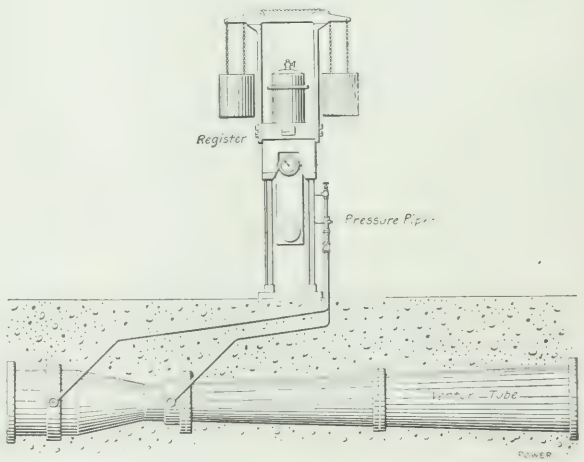


Fig. 1. Venturi Meter and Register

When the water in the meter tube and in the pipe lines is at rest, the pressure in the throat-pressure chamber is the same as that in the upstream-pressure chamber. During the flow of water the throat pressure becomes less than the upstream pressure, the difference between these two pressures being proportional to the square of the velocity of the water. The register is affected by these two pressures and automatically translates the results into gallons which are indicated on a direct recording counter dial.

Fig. 1 shows a general view of one of the registers used with this type of meter, and in Fig. 2 are given the details of this device, illustrating the principle upon which it works, the whole arrangement being in effect a differential pressure gage. The mercury level in the mercury tube raises and lowers a float to which is secured the float stem carrying on its upper end the roller arm and the roller, the latter being held by a spring against the integrating drum. The drum is revolved (usually six times per hour) by means of the weights shown in Fig. 1; when a lever in the power mechanism is lifted by the movement of a clock, the suspended weights, acting through a series of gears, revolve the integrating drum. If water flows through the meter at a rate sufficient to raise the float so that the roller is brought to the level *A*, on the integrating drum, the roller will be in contact with the raised

surface and through a lever not shown will cause a pinion driving the indicating drum counter to be unmeshed. As the integrating drum revolves in the direction indicated by the arrows the roller will move on the raised surface on the other side of the drum directly opposite the line *A B;* when it reaches the point *B* on the drum it will be pulled on the depressed surface by the spring and the pinion will mesh with the counter gearing and move the counter figures ahead, corresponding to a 10-minute flow of water through the meter; this amount of water corresponds to the differential pressure with the roller at *A*. Needless to say, the curve formed by the line between the raised surface and the depressed surface has been carefully calculated to give the correct counter reading.

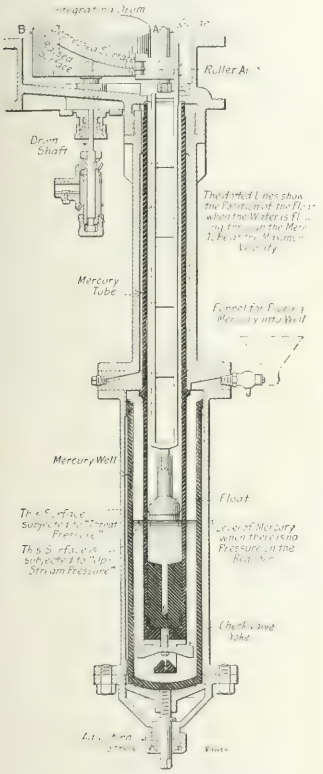


FIG. 2. DETAIL OF REGISTER

In Fig. 3 is shown a register for use in connection with venturi meters; this has an indicator dial, a counter dial and a recording dial, and it is an instrument admirably adapted for checking accurately the flow of the feed water to the boilers.

The writer has six venturi meters with registers of the type shown in Fig. 1, and has found it necessary in the case of one installation to provide a special air chamber so as to lessen the effect of the pulsations from the boiler-feed pump. Such an air chamber is illustrated in Fig. 4.

When the venturi meters were first purchased it was decided to test the accuracy of one of the registers. For this purpose a 4-inch meter tube was connected through a pipe line to a tank fitted with a float and with an accurate water-level indicator. At the same time the constant K of the formula

$$v = K\sqrt{2gh}$$

was determined for a set of Pitot tubes. Many runs were made and the results were as given in the accompanying table.

From this it appears that the register and the meter tube tested showed an average error, within the proper working limits of the register of 1.64 per cent. of the total water measured. This is an excellent showing and is more than sufficient for the requirements of most boiler plants.

If the flow of water is very irregular and fluctuating and if the measurements cover a short period of time only, the register shown in Fig. 2 is apt to be more inaccurate than the tests indicated. This is so because the working principle of the register is based upon the assumption that each 10 minutes' flow is constant and of a magnitude corresponding to the position on the roller on the integrating drum of the register at the time of registration. If measurements of the flow must be made covering short periods of time only, then the chart recorders, as shown in Fig. 3, will be more suitable.

TANK MEASUREMENTS, VENTURI METER REGISTER AND PITOT TUBES

Discharge in Gallons per Hour through Venturi Meter					
Tank	Register	Pitot Tubes	Error of Register, Per Cent.	H in Pitot Tube, Inches of Water	Constant K for Pitot Tube Used in $v = K\sqrt{2gh}$
572	No record	1,120	..	0.05	0.511
805	900	1,590	+10.5	0.1	0.506
1,467	1,550	2,255	+ 5.7	0.2	0.651
2,557	2,600	3,563	+ 1.9	0.5	0.715
4,295	4,300	5,840	+ 0.001	1.35	0.735
6,050	5,975	7,720	— 1.1	2.375	0.784*
7,587	7,400	9,987	— 2.4	4.00	0.76
7,594	7,450	9,987	— 1.7	4.00	0.76
7,629	7,400	9,987	— 2.8	4.00	0.763
8,499	8,350	10,975	— 1.55	4.75	0.775
8,577	8,400	11,210	— 2.0	5.00	0.765
8,968	8,350	11,800	— 7.00†	5.5	0.76
10,821	8,350	14,100	—23.00†	8.0	0.768

*Discharge not kept constant. †Above maximum limit of register.

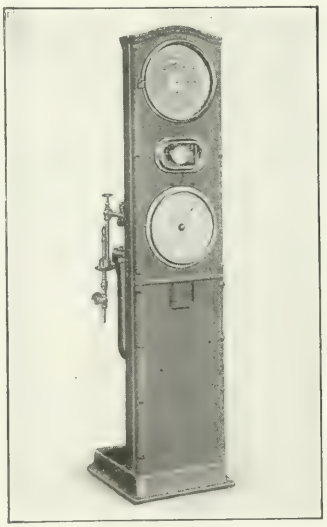


FIG. 3. INDICATING, INTEGRATING AND RECORDING INSTRUMENT

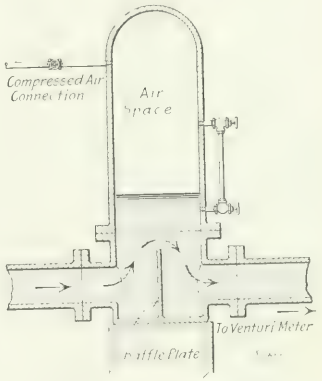


FIG. 4. AN AIR CHAMBER

THE PITOT TUBE

This method of measuring water would seem especially suited for boiler-feed water. It has practically the same advantages as the venturi meter in that solid particles can neither stop the working of the device nor impair its accuracy; any sediment which might collect in the tubes can easily be blown out.

In Fig. 5 are illustrated the essential features of the Pitot tube in position for determining the velocity of a current of water flowing along its bed with the free

surface at *B*. This instrument consists simply of a plain piece of glass tube bent 90 degrees at the lower end and placed with the open mouth *A* facing the current, while the other end extends above the surface *B*. When the water drives against the open end, a pressure results from the impact which causes the water to rise within the tube to a hight *H*, this

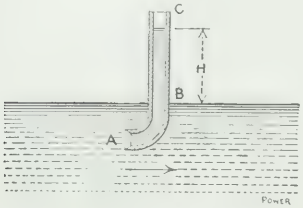


FIG. 5. ELEMENTARY PITOT TUBE

head of water being proportional to the velocity of flow. Pitot concluded that this head was simply that due to the velocity v of the current, so that

$$v^2 = 2gh,$$

where g is the acceleration due to gravity. This formula is that for falling bodies and also that for Toricelli's theorem for the velocity of water issuing from an orifice.

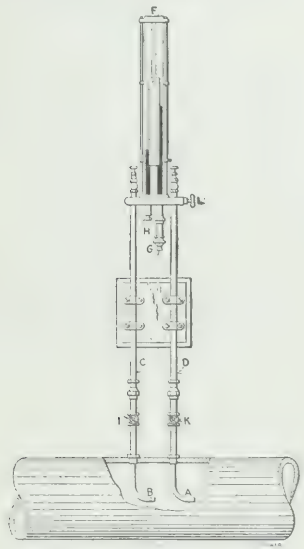


FIG. 6. INDICATING INSTRUMENT FOR PITOT TUBES

An indicating instrument for pipe lines under pressure is illustrated in Fig. 6. The difference in the water levels is shown by manometer *F*, which is practically a differential-pressure gage. This value h is used in the formula

$$v^2 = 2gh$$

and knowing the area of the pipe at the points of insertion of the Pitot tubes the quantity of water passing these points is readily computed.

It should be noted that the velocities of the water at different points of the same cross-section of a pipe are not the same. The average velocity is found at a point somewhere between 0.7 and 0.75 of the distance of the impact tip from the center of the pipe. It is impossible without much work always to get the impact tip at the point of average velocity.

From experiments it has been found that the shapes of the Pitot tubes have considerable influence on the constant K in the formula

$$v = K\sqrt{2gh}$$

One objection to the Pitot tubes described is that they are indicating instruments only. To measure constantly the flow of water in boiler-feed lines, a recording or an integrating instrument is necessary. At present no differential-recording gage is manufactured which could be used in connection with Pitot tubes for measuring the velocity of liquids. There is, however, a differential-recording gage which is used much abroad and also to some extent in this country for the continuous determination of the velocity of gases in metallurgical works, coke ovens and gas plants; also for the measurement of compressed air and for determining the velocity of air in ventilating systems. At the present time this instrument is used for the measurement of gaseous fluids only, but, with some slight modification in the installation it could, no doubt, be adapted for the measurement of liquids also.

TURBINE-WHEEL METER

Fig. 7 shows a turbine-wheel meter which, properly speaking, comes under the heading of velocity meters and is used to a considerable extent for measuring hot boiler-feed water. An excellent feature is its simplicity. Like the venturi meter and the Pitot tube, if this turbine-wheel meter is connected into the discharge line of the customary boiler-feed pump, there should be inserted in the line a large air chamber to lessen the pulsations of the pump. In the test of a 6-inch meter of this type it was found to be accurate within 0.2 of 1 per cent.

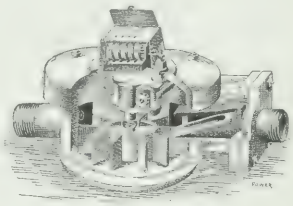


FIG. 7. TURBINE WHEEL METER

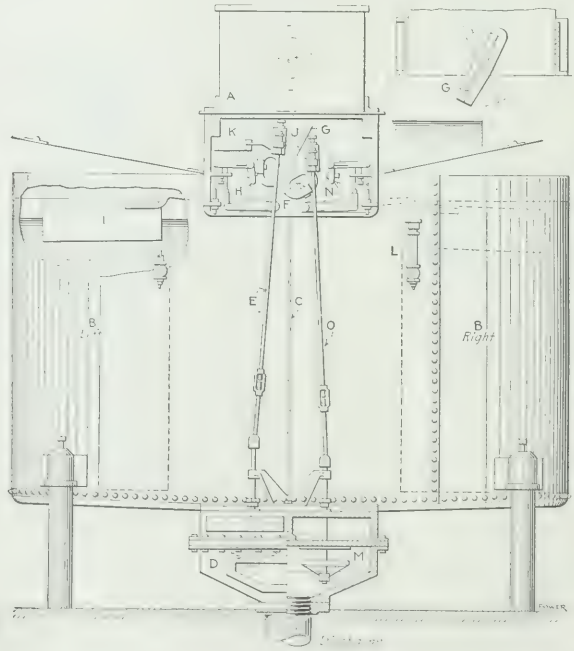


FIG. 8. HAMMOND WATER METER

Volume Determinators

Meters belonging to the class of volume determinators suitable for the measurement of hot water are in many cases of the piston type. All piston-type meters must be designed for a certain fixed range of feed-water temperature. For this reason, in plants where the feed water is sometimes pumped into the boilers cold and at other times moderately hot or near the boiling point, the piston type of meter is not so well suited.

Hammond Water Meter

The Hammond water meter for measuring water at any temperature is illustrated in Fig. 8. It consists of a receiving tank *A* and a measuring tank *B* which is divided into two compartments by the partition *C*. The liquid enters *A* and flows through a slot in the bottom to the measuring tank *B* in which are placed the discharge valves *D* and *M*, opening downward from each compartment; these discharge valves are held to their seats by the valve rods *E* and *O* attached to the wristplate *F*. The inlet valve *G* is connected to the wristplate on the same shaft.

With the inlet valve and the wristplate in the position shown and the water flowing into the left side of the measuring tank, the discharge valve *D* is held to its seat by the wristplate, which, in turn, is held by latch *H*. As the water rises in this compartment it lifts the float *I*, which causes the latch *H* to unhook and release the wristplate. The weight of water on the discharge valve *D* instantly pulls the valve down and rotates the wristplate, thus turning the inlet valve *G* so as to deflect the incoming water into the right side of tank *B*. At the same time the wristplate draws the discharge valve *M* to its seat where it is held up by latch *N* and the water now flows into the right compartment. There are springs at *J* in the heads of the valve rods which hold the discharge valves to their seats and keep them from leaking. The wristplates and the latches are provided with hook blocks similar to those on the valve gear of a Corliss engine, and are made of hardened steel. The operation of the meter is automatic and continuous, a record of the cycles of operation being tallied on a revolution counter.

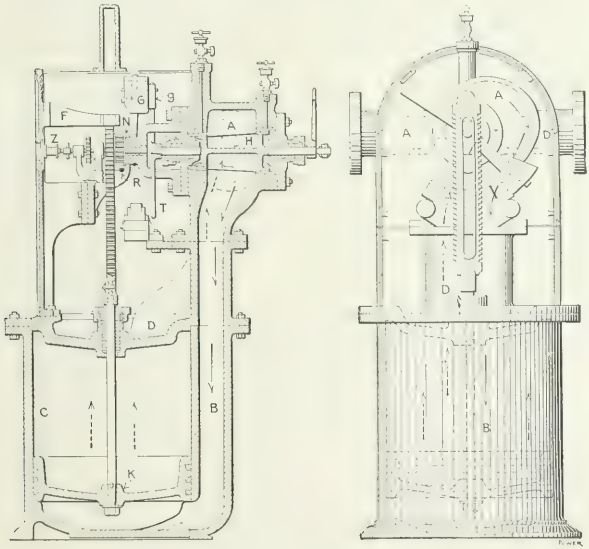


Fig. 9. Eckhardt's Water Meter

Eckhardt's Feed-water Meter

The working of this meter is illustrated in Fig. 9. The meter is placed in the feed line between the feed pump and the boilers, and the water enters and leaves through a four-way valve so arranged that there is always an unobstructed passage from the pump to one side of the piston *K* and an open passage from the other side of the piston *K* to the boilers. When the piston is at the bottom, as shown, water enters under it through the port *A B*, lifting the piston and pushing the water above it through port *D* to the boilers. The double rack which is connected to the piston rod drives the gear *N* and this is provided with a small projecting lever through which an arm carrying the weight *G* is lifted. This arm with the attached weight is raised until it falls over on the other side by reason of gravitation. During the turning over of the weight a projection engages a double lever *T* which operates the four-way valve. In this manner the discharge and entrance of the water to the meter are reversed. The piston now descends and the entire mechanism again goes through the same cycle. Through a train of gears the number of piston strokes is recorded by a counter.

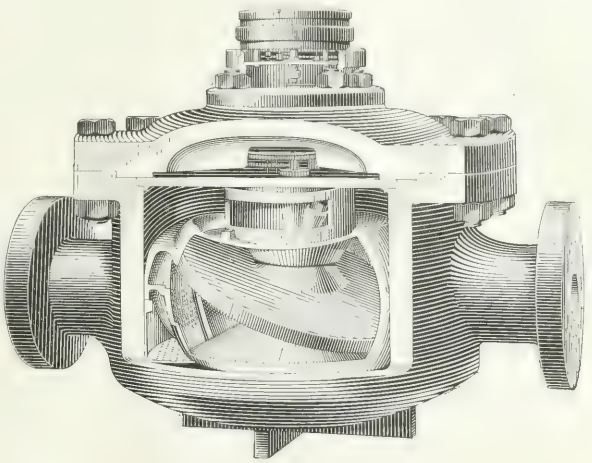


Fig. 10. Siemen's Disk Meter

In a series of 57 tests, during which the water was carefully weighed on a scale and the temperature of the feed water ranged from 80 to 140 degrees, this meter showed an average accuracy of 0.47 of 1 per cent. This high degree of accuracy is readily understood when it is remembered that practically no water can pass the piston unmeasured.

Siemen's Disk Meter

The Siemen's disk meter, shown in Fig. 10, is manufactured in Germany, although used extensively in this country.

Because of its relatively small size it may be connected practically anywhere into the boiler-feed line. Every oscillating motion of the measuring device fills and empties the measuring chamber at every turn similar to the piston displacement in the piston type of meter. One advantage claimed for this meter is its certainty of operation because of the complete expansion permitted to all working parts in all directions even by quickly changing temperatures of the feed water. Another advantage is the small repair bills necessary by reason of its simple construction, and no lubrication is necessary because of the carbon compositions used in the meter.

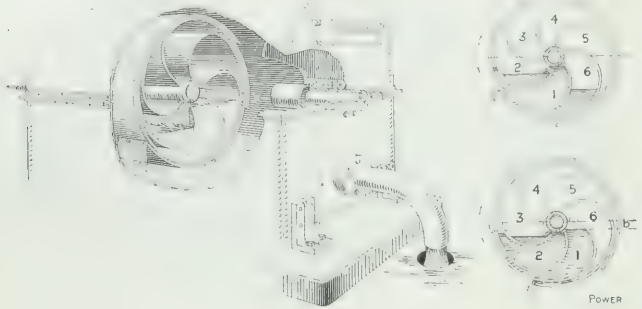


FIG. 11. REVOLVING DRUM METER

REVOLVING DRUM METER

In Fig. 11 is shown a drum meter of great accuracy. Dirty water, hot water, oils, etc., can be measured in this device with satisfaction.

The hollow shaft provided with a slot through which the water enters is held rigidly in place while the drum resting on rollers revolves around the shaft. The compartments of the drum are filled successively in such a way that always the one directly underneath the slot flows over; not until the compartment is overflowing can the drum move; sufficient water must first have flowed out of compartment 1 into compartment 2 before any motion can occur. The overflow from compartment 1 into compartment 2 continues until the discharge is as high as the water surface *a b*. But meanwhile compartment 1 has moved away from the slot in the rigid shaft through which the water enters so that the exact measure in the compartment is given at the very moment when the exit *a* stands as high as the water level in compartment 1. When the meter is in operation the center of gravity of the drum lies so that the direction of rotation is as indicated by the arrows. Each rotation of the drum is recorded and the quantity of water passed through the machine is thus measured.

WORTHINGTON STANDARD WATER METER

The Worthington standard water meter is of the well known duplex pump; the water is taken into the meter and discharged by two reciprocating plungers. Ports in the base of the meter admit and discharge the water. The chambers at either end of the plungers are alternately placed in communication with the inlet and discharge openings through the medium of small D-valves, these valves being actuated by the plungers in their backward and forward movements. One of the plungers imparts a reciprocating motion to a lever near the top of the main casing, which, in turn, operates the counter movement through a spindle and ratchet gear.

This type of meter is not suited to measuring feed water of greatly varying temperatures, but when used under the condition for which it is designed and when properly adjusted it gives excellent satisfaction.

WEIGHT DETERMINATORS

The Worthington recording liquid weigher, illustrated in Fig. 12, consists of two measuring tanks of equal size *A B*, each fitted at one end with a siphon pipe *C* and at the other end with weights *D*. The tanks are balanced on the knife edges *K*, which are located at less distance from the counterweights *D* than from the siphon pipes *C*. The liquid to be measured flows through the inlet pipe either tank. The weights *D* are so adjusted that the tanks will remain in a horizontal position until they contain a certain definite weight of liquid; then they will tilt into the position shown by the dotted lines and the liquid will begin to flow through the siphon pipe. After the level of the liquid in the tank has fallen sufficiently, the tank tilts back again to its original position by the influence of the weights and the siphon continues in action until the tank is emptied. As each tank assumes the position indicated by the dotted lines it tilts over suddenly the deflector *F* so that the liquid does not continue to flow into that tank, but begins to flow into the second tank, where the operation is repeated. As each tank tips, the number of pounds contained is registered on a counter *G* which is actuated by the deflector *F*. It should be noted that the tilting of the tanks is accomplished entirely by the introduction into them of a definite weight of liquid, irrespective of variations in volume due to specific gravity or variations in temperature.

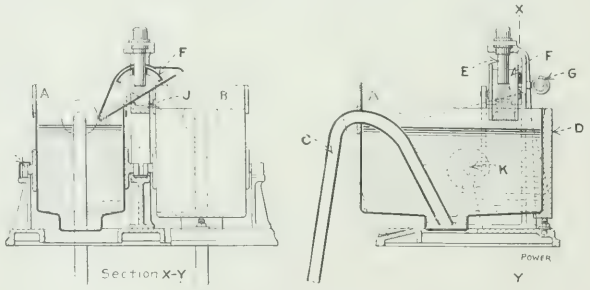


FIG. 12. WORTHINGTON WEIGHT DETERMINATOR

WILCOX WATER WEIGHER

Fig. 13 shows a water weigher which is used in many boiler houses and which seems to give universal satisfaction. The principle of this weigher consists in balancing the charge of water by a water column of fixed hight through the medium of an air cushion and then dumping the weighed charge automatically by releasing the cushion. The weigher is a tank divided by a diaphragm into an upper and a lower compartment; the former stores the entering water while the latter dumps the previously weighed charge. Projecting into the bottom of the lower compartment is a large U-shaped discharge pipe, always water sealed, and its projecting end is surrounded by a bell float which has a small up-and-down movement.

In the upper compartment is a standpipe, open at the top and bottom. The float and standpipe are connected by a rod so that they move together as one rigid piece, this being the only moving

the standpipe is corrugated on its face, and when down its face rests on a soft ring surrounding an opening in the diaphragm. Water entering the inlet accumulates in the upper compartment until it overflows at the top of the standpipe. The water then spills down through the standpipe into the lower compartment and accumulates there until it lifts the bell float. As the float rises it lifts the standpipe from the opening and allows the accumulated water from the upper compartment to flow into the lower one. After the upper compartment empties, the inlet water flows along the bottom underneath the raised standpipe and into the lower compartment and gradually raises the level in the lower compartment until the dumping point is reached, which corresponds to a definite weight of water.

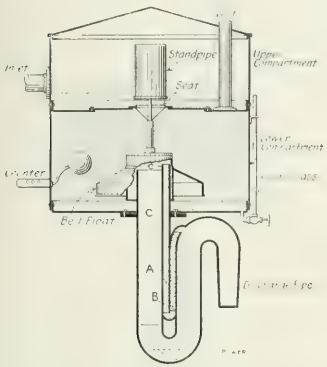


FIG. 13. WILCOX WATER WEIGHER

The weighed charge is at this moment automatically released and dumps through the large discharge pipe.

When the unit charge has begun to accumulate in the lower compartment, the air entrapped in the bell float and in the upper part of the discharge pipe is compressed. It should be remembered that the lower bend of the discharge pipe is always water sealed; that the air pressure in the bell float increases as the head of the water in the lower compartment increases, and that it balances exactly at all times the weight of the accumulated water.

In order to dump or trip the charge when the exact weight is reached it is only necessary to release the air suddenly from the bell float at the right instant and to permit the weighed charge to escape through the discharge pipe. This dumping is accomplished by means of a trip pipe that communicates with the compressed air in the discharge pipe just below the bottom of the lower compartment. The trip pipe is a manometer, normally water sealed, which automatically unseals itself at the dumping point in order to release the weighed charge. While the air pressure in the bell float and in the upper part of the discharge pipe increases, due to the accumulating charge, the water in the left-hand leg *A* of the manometer is slowly pushed down and a corresponding amount spills over the upper end of the right-hand leg *B* into the discharge pipe, forming a part of the next unit charge. This amount is a constant and is taken into account in calibrating the weigher. The lowering of the water level in leg *A* of the manometer continues until the level reaches the bend of the manometer. The water column in leg *B* is at this instant exactly balanced by the weight of water in the tank through the medium of the air cushion *C* in the bell float and the discharge pipe. If now only a few additional drops spill from leg *B* of the manometer to the water in the tank, the equilibrium is destroyed and the weighed charge dumps. The air in the bell float and in the upper part of the discharge pipe, which has been highly compressed by the water accumulated above it, suddenly blows the water from leg *B* of the manometer; then the air rushes through after the water. The bell float now drops, and the weighed charge siphons out of the lower compartment through the discharge pipe. The instant the bell float drops, and it drops very suddenly, it seats the standpipe in the upper compartment; by the downward pull, due to the water pressure above, the bell float and the suction of the siphon below hold the standpipe in place, thus preventing entrance of water from the upper compartment into the lower compartment while the unit charge is escaping.

When the standpipe seats as described, inlet water again begins to accumulate in the upper compartment until it once more overflows and the cycle of operation is repeated. A lever-operated mechanical counter, located conveniently on the shell of the weigher, records each weighed charge as it leaves the weigher. A gage glass provided on the weighing compartment shows the cycle of operation at a glance. Each weigher is guaranteed to weigh within 1 per cent. of absolute accuracy at any temperature from freezing to boiling.

Examiners and Licenses

BY JOSEPH KING

Looking up from the coal and water reports I had been figuring, I warmly greeted the young man who had formerly oiled for me, and who, much to my regret, had left me to locate in the western part of the state where he had figured a license could be more easily secured than in his home district. I had failed to find a satisfactory answer to his persistent question, "Why would I not have a better chance to secure a license in a district where the reports showed that 90 per cent. of the applicants were granted licenses, than in a district where only 49 per cent. were successful, and where I have twice been 'turned down'?"

"Well, my boy," I asked, as he drew up a chair, "how did your plans work out? You had your 'chances' pretty well figured out, so I suppose you walked right in and pulled out a 'first' with the same ease that the boys around these parts would get a second-class fireman's license?"

PLAYED IN TOUGH LUCK

"No," he replied, "I played in tough luck. I got a job all right, but instead of starting right in and taking my examination as soon as I had secured a 'residence,' I kept putting it off, and the first I knew the examiner I had taken so much trouble to become friendly with, was removed for some reason. When I went before his successor, I found him just as hard as the rest of them. It is strange that I cannot get a better license.

"Here I have been working in half a dozen plants in this state, and I have worked in plants all the way to California; I have fired boilers, run engines and worked in large plants, and I have 'made good,' or at least my employers have all tried to have me stay with them when I wanted to leave. They gave me good recommendations, yet when I come back to Massachusetts, where I want to locate, I can't convince the examiner that I am competent to hold an engineer's license."

His earnest manner of speaking warned me that levity on my part would be unseemly, so instead of commenting on the good opinion he evidently had of himself, and which I knew from his service with me was justified, I asked why it was that, with his experience, and the knowledge he had acquired from engineering books and magazines, and the seemingly inexhaustible stock of examination questions for which he was always seeking answers, he had so far failed to make a favorable impression with the examiners?

THE PERSONAL ELEMENT

He thought for a moment before answering. "It is because the personal element of the license law is allowed to enter into the examination room. I have been before several of the examiners and each has impressed me in a different way. Each one seems imbued with the idea of examining a man to find out how much he does not know about the business, and, believe me, they have a large field to work in. One examiner may confine his questions to subjects which require the use of certain formulas in answering. You may know where to look for the formula in the pocketbook but you are not allowed to consult such indispensable companions of the 'practical'

working engineer, so if you have not committed to memory the thousand and one rules and formulas to which the examiner resorts, you must eventually fail and be told to 'come up again.'

"The worst of all is the one who 'fires' his questions at you with the rapidity of a machine gun and changes from one subject to another, and who, when you have failed on some trivial question that he must know you could have answered had you been given time to consider, exhibits the same demoniacal glee as does the cheerful idiot at a party when he propounds a riddle the answer to which is so simple as to make you feel foolish that you did not think of it."

"But," I interrupted, "you have a chance to appeal if you feel aggrieved at the action of the examiner."

Oral versus Written Examinations

"Huh! What does that get you?" he responded. "You can go before three examiners who give you an entirely different examination from the one you made the kick over, and anything you may have observed detrimental to your chances of compelling the original examiner to grant the license can just about be multiplied by three when you go before the board. Why do they not have the examinations in writing so that the questions asked and the answers given can be submitted to an impartial board to determine whether the examiner erred in refusing to grant the license? The examinations for boiler inspectors and for chief inspector are given in writing, and it seems to me that a man after a permit to work at his trade is entitled to the same consideration as the seekers of positions higher up.

"They do not want to lose the despotic power of giving and denying licenses as they see fit, that's why. Think of the treatment accorded the late W. E. Crane, a man whose experience and versatility in answering engineering problems entitled him to be classed with the prominent operating engineers of the country. When he applied for a first, he was offered a second-class engineer's license, and when surprise was expressed, it is reported that the examiner's reply to an inquiry was that he did not know it was that W. E. Crane."

Variation in Percentages

Without waiting for a response, my young friend put on his overcoat and, taking from a pocket a loose-leaf notebook, he removed a page (the figures for which are given in the accompanying table) which he passed to me, saying:

"Here is a list of percentages of licenses granted by each inspector as compared to the whole number of applicants examined by him for the years 1908 to 1910. Look it over, and when I come in again I shall expect you to explain why there should be such a variation as 90 per cent. and 22 per cent. in the same year, and why certain examiners should maintain such a low percentage of licenses granted from year to year if there is any standard for conducting examinations. In fact, see if a study of the list does not tend to corroborate my statement that the form and manner of conducting license examinations in Massachusetts are responsible for much unnecessary injustice to the applicants for licenses."

PERCENTAGE OF ENGINEERS GRANTED LICENSES

Inspector	1908	1909	1910
A	55	55	62
B	50	44	51
C	60	63	58
D	57	50	49
E	40	48	36
F	60	58	50
G	53	53	44
H	47	35	52
I	47	35	46
J	32	31	26
K	37	31	
L	37	31	35
M	37	28	34
N	21	22	30
O	79	73	66
P	33	45	39
Q	44	46	48

Use of Exhaust Steam

In a paper read by P. Barrett Coulston before the Manchester Geological and Mining Society on the use of exhaust steam, reference was made to a colliery where noncondensing engines of 1200 hp. per hour were installed. An exhaust-steam turbine, taking about 36,000 lb. of steam, with an electric generator and condensing plant, was then installed, with the following result:

The exhaust steam from the engine which drives the turbine plant gives 1000 kw. or, say, 1500 i.hp.; the 36,000 lb. of steam which must still be generated now yield 2700 instead of the original 1200 i.hp.; and the additional power obtained from the electrical set is being used for different purposes throughout the colliery.

Another example given is that of an engine of 1000 i.hp. which, when condensing, takes 15,000 lb. of steam per hour, and when run noncondensing, gives 900 i.hp. for 20,000 lb. of steam per hour. When the engine is noncondensing and the exhaust steam passes through a supplementary turbine, an additional 940 i.hp. is obtained, giving a total output for 20,000 lb. of steam, of 1840 i.hp. When the load demanded from the engine and turbine is reduced to 1000 i.hp., as happens during certain periods, it is obtained for 13,000 lb. of steam per hour; and, moreover, the combination remains more economical than with the engine alone running condensing until the load falls to between 400 and 500 i.hp.

Mr. Coulston recalls that the function of the exhaust-steam turbine lies in the capacity which it evinces to make efficient use of the higher vacuum, for the combination of a steam engine and the exhaust-steam turbine is simply that steam is passed through the engine, in which it does a certain amount of useful work, and then to the turbine, in which its remaining energy is used. Three items beyond dispute are: 1, the capital expended in the installation of the exhaust-steam turbine is low, being only that of the turbine set and its condenser; 2, the space is so small that the plant can almost invariably be installed in the existing engine room; 3, the pipe connections are very simple.

Increased efficiency is the chief advantage of the exhaust-steam turbine, due to either excess power for the same quantity of coal expended, or the same power for less coal.

In colliery work especially, the only possible way in which to utilize the exhaust steam is by means of a turbine. By the introduction of what is termed a "regenerative thermo-accumulator" it is a simple matter to supply steam to the turbine continuously, although the supply of steam from the engine to the accumulator is of an intermittent nature.

The type of accumulator most generally used, it is explained, is that of a large vessel or container filled with water or other material having heat-storing properties. The exhaust steam from the engine is led into this receptacle, and then supplied to the turbine. When the engine is running and supplying more steam than can be used by the turbine for the time being, the surplus is condensed in the accumulator at about atmospheric pressure, and the temperature and the pressure of the water rise gradually as more steam is condensed. When the engine stops, a drop in pressure at once occurs. As the steam is being constantly used by the turbine, recuperation takes place, and sufficient steam is supplied to the turbine to bridge the gap between the time of starting and stopping the engine.

It is pointed out that where the stoppage of operations is of too long duration to be bridged by an accumulator of normal size, it is only necessary to fit a reducing valve, by which means live steam from the boilers can be automatically supplied to the turbine when the pressure in the accumulator falls below a predetermined figure.

Mr. Coulston concludes by saying that the capital cost of the turbine is at least as low as that of any form of prime mover, while from the point of view of running costs, all the power recovered is pure gain; for, after passing the steam through the turbine, it becomes condensed, and may be again fed to the boilers, thus obviously saving water, which, in some cases, at any rate, is an item of no small value.

The world's total coal production in 1910 was approximately 1,300,000,000 short tons, of which the United States contributed about 39 per cent.

Fuel Economy and CO_2 Recorders

By A. D. Williams

A review of the subject of combustion and fuel economy. CO_2 alone is not a perfect index of combustion efficiency.

Three types of automatic CO_2 recorder are discussed. The fireman can cheat the intermittent type.

Fuel economy is an important item of power-plant economy, but in most plants the only method of determining fuel economy is by a comparison of the amount of fuel burned in securing a unit output with past records. This may be a very crude method, but in the final analysis the number of cents' worth of fuel consumed in turning out a dollar's worth of product is the real test of economical combustion. The actual cost of any fuel is not that nominal price found on the bill of the dealer supplying it, but includes a number of other items, such as the cost of unloading into the bunker, of moving from the bunker to the fire, of removing the ashes and disposing of them and the interest on the average amount of capital tied up in the reserve supply of fuel. The number of pounds of coal burned per unit of product will vary with the thermal value of the fuel, the amount of ash it contains and the economy with which the process of combustion is effected. The temperature and the proportion of the gaseous components of the products of combustion must be known in order to definitely fix the economy of the process. The quantity of unburned combustible in the ash is also a step in fixing the plant fuel economy.

Theoretically perfect combustion is unobtainable except under the most favorable laboratory conditions, and even then the chances of success are slight. In the boiler room the process of combustion must be reduced to commercial values and the failure to maintain the steam pressure cannot be atoned for by reduced fuel consumption. There are four important factors which tell the story of fuel economy as indicated by the flue gases, carbon dioxide; carbon monoxide, oxygen and sensible heat. By itself, the percentage of carbon dioxide is only an imperfect indication of the economy of combustion.

Combustion is a complex chemical reaction and in a boiler furnace and setting there is often primary combustion in the furnace and secondary combustion in the gas passages; the latter is due to a partial combustion in the furnace forming carbon monoxide which burns to carbon dioxide by combining with oxygen entering the flue through leaks in its wall or leaks in the boiler setting. The composition of the gases of combustion will vary considerably at different points in the combustion chamber, the percentage of carbon dioxide usually increasing as the distance from the fuel bed increases. This is due to the fact that the chemical reactions occurring require an appreciable time and to secondary combustion. A low percentage of carbon dioxide may be accompanied by a surplus of carbon monoxide or oxygen or a surplus of both, and high percentages of carbon dioxide and carbon monoxide may occur simultaneously with surplus oxygen. The chemical union of carbon and oxygen generates heat, but this union does not occur if the gases are below the ignition temperature. Unburned volatile hydrocarbons may be lost in this manner.

Carbon-dioxide recorders are generally connected to the smoke flue immediately outside of the boiler setting. The point of attachment should be the same at all flues to insure the proper comparative value for the diagrams from different boilers. As the recorder itself is a delicate piece of apparatus, it must be placed where it can be watched and receive proper attention. Therefore it is necessary to introduce a pipe connection of greater or less length between the recorder and the boiler flue from which the gases are to be drawn. This pipe connection introduces the element of time lag between the record and the flue condition it represents, as an appreciable time will be required for the gases to pass through the pipe to the recorder. The time lag can be reduced by the use of an aspirator to keep up a continuous flow of flue gases in the connection pipe. One of the advantages arising from a long pipe connection is the opportunity it affords for the cooling of the flue gases.

Carbon-dioxide Recorders

Many carbon-dioxide recorders are fragile and require a certain amount of attention and a delicate touch. This apparatus has often been placed under the care of a man who, while intelligent enough for the purpose, had a hand trained to the shovel or a big monkey wrench; he did the best he could, but the recorder suffered. This kind of attention has caused a number of recorder installations to go out of service.

In method of taking samples there are two types of recorder, one in which the sample is taken at intervals of from five to ten minutes or more; the other in which the sample is passed through the apparatus in a continuous stream. This last method is inherently more accurate than any other as it furnishes a sample which tells the story at every minute the recorder is in operation.

The intermittent-sampling method may be accurate enough as to the analysis of each sample, but there is nothing to tell what is happening in the interval between the taking of samples. This interval has to be sufficiently long to permit the potassium-hydrate solution to absorb the carbon dioxide, and as a fresh solution acts more rapidly than one nearly saturated with gas, the time must be fixed to suit the slowest-acting solution; otherwise the accuracy of the indication will be seriously impaired.

One of the serious disadvantages of the intermittent method of sampling arises from the fact that the fireman can readily approximate the time interval and lag of the apparatus and so arrange his work that the admission of surplus air to the furnace occurs during the periods when samples are not being taken. This will result in a good card on the recorder but one which is not a fair representative of the operating condition under which it is supposed to be taken. Beating the recorder in this manner is particularly liable to occur in plants where the firemen receive a bonus based on the recorder indications.

Continuous-sample Recorders

Continuous-sample carbon-dioxide recorders are of two types, one in which the specific gravity of the gases flowing through the machine is indicated by a delicate balance; the other operating upon the principle of the flow of gases through small orifices into a partial vacuum. The differences in weight due to varying percentages of carbon dioxide are extremely slight; therefore the scale or balance capable of detecting and indicating these changes in the specific gravity of the gases is a very delicate one. Apparatus of this kind must be accurately leveled and so located that it will not be subjected to vibration or shocks. The more sensitive this scale the less is its suitability for a place in the boiler room.

One of the weakest points about the balance type of construction arises from the necessary exposure of the metal parts of the apparatus to the waste gases, which frequently are of a corrosive nature owing to the presence of sulphur dioxide. Glass parts and agate knife edges are occasionally used, but these last will gradually lose their accuracy. This type of recorder may be supplied without the automatic recording device and used as a carbon-dioxide indicator.

he third type of carbon-dioxide re-
der consists of a chamber into which
gas flows through a small orifice and
n which it is drawn through an orifice
he same size, into a chamber in which
artial vacuum is maintained. Means
provided by which the flowing gas
the orifices through which it passes
maintained at a constant temperature.
long as the same volume of gas passes
ough both orifices the vacuum in the
t chamber will be one-half the vac-
n in the second chamber; but if after
sing the first orifice one of the con-
uents of the gas is removed, its vol-
e is reduced and the vacuum in the
t chamber will be increased. This
rease in the vacuum will be an exact
asure of the volume of gas absorbed.
the carbon-dioxide recorder operating
on this principle the first chamber is
ed with quartz pebbles which are kept
ist with a solution of potassium
droxide flowing over them from a
avity source of supply. This provides
arge amount of absorption surface and
continual supply of fresh solution. The
fference between the vacuum in the
st and second chamber is recorded up-
a chart actuated by a clock movement.
The records of all carbon-dioxide re-
rders should be checked from time to
ne by the use of the Orsat apparatus,
d, where possible, this apparatus should
used daily. This is probably the most
idely known and used device for flue-
as analysis. It enables a quantitative
etermination of carbon dioxide, carbon
onoxide, oxygen and nitrogen to be
ade in about one-half hour, including
e time necessary to secure the sam-
le. This apparatus is portable and con-
enient. Where this apparatus is used
close check can be kept upon the con-
itions of the boiler settings and the
mount of air infiltration as samples of
he gases of combustion can be obtained
rom any part of the setting or the gas
assages.

As temperature and barometric pres-
ure affect the volume of the flue gases
nd furnace conditions, it is advisable
o use a recording thermometer or
hermograph supplying a record of the
emperature of the air and the flue gases.
A barograph or recording barometer for
keeping track of the barometric condi-
ions and a recording draft gage are also
desirable additions to the power-plant
aboratory. This latter apparatus, how-
ever, can be dispensed with; in fact,
most power plants consider they have
gone the limit on boiler-room jewelry
when they put in a recording steam gage.

The boiler room is the place where the
biggest opportunity for cutting down op-
erating expenses lies and the chemical
reactions occurring in the boiler furnace
must be carefully watched in order to
attain practicable efficiency.

A complete set of records of this char-
acter covering one or two years would be invaluable in settling many of the complex points involved in power-plant operation and would supply an interesting light upon the subject of chimney draft. In this last case, the record should be accompanied by information as to the number of boilers in operation at all times and to the steam temperatures and pressures maintained.

Hoisting Engine Repair Job

Looking at the long lines of mine steam pipes, some of them 3500 ft. long and over, the problem of taking care of the condensed steam is apparent. This condensate is taken care of by means of traps and separators, but occasionally these devices fail to operate and a wrecked engine is the result.

One morning, several years ago, after a 32x48-in. first-motion hoisting engine had been running as usual for about an hour, both cylinders received a slug of water which resulted in cracking both engine frames on the under sides of the

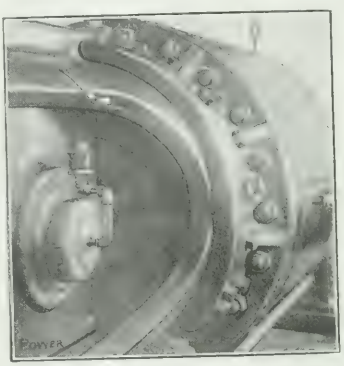


FIG. 1. CASTING FITTED TO FRAME OF ENGINE

throat, next to the flange where it is bolted to the cylinder. The engine bed was also broken on one side at the pillow block, either one of the fractures being so severe as to render the engine useless until a new frame could be obtained or repairs made.

Chief Machinist Morgan, of the Susquehanna Coal Co., at Nanticoke, Penn., decided upon and carried out the repairs as follows: A heavy casting was made to fit on the outside of the engine frame and was flanged to the same size as the frame and the cylinder. Long stud-bolts were used instead of the engine studs, and clearance holes were drilled in the casting to match those in the engine frame. Another set of holes were drilled and tapped in the frame and corresponding holes drilled in the casting. Cap-bolts were then screwed tightly in place. The nuts on the stud-bolts were then screwed up tight. Ribs were made on the casting to strengthen it. A 1¼-in. rod was screwed into the base of the engine frame on each side of the cylinder and also pressed through the foot at the head end of the cylinder. These rods were made tight by nuts and the whole served to prevent the cylinder from pulling away from the frame; both cylinders were treated in the same manner. The repair is shown in Fig. 1.

Securing the pillow block to the frame was a more difficult job, but it was ac-

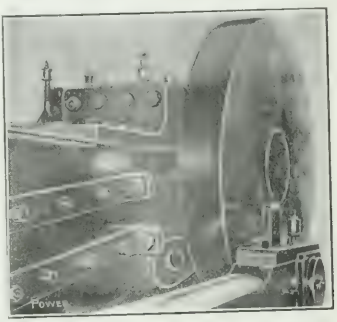


FIG. 2. SPECIAL PILLOW BLOCK CAP FITTED TO FRAME

complished by making a new cup for the bearing, having a shoulder cast on the inner end. A special casting was made to butt against this shoulder and to extend out on top of the engine frame, as shown in Fig. 2. The two shoulders were held together by five 1½-in. bolts; the angle casting was secured to the engine bed by eleven 1-in. capscrews.

On each side of the frame two angle irons were secured by 1-in. bolts and the

FIG. 3. APPLICATION OF CASTING AND TIE RODS

angle end of each was drilled for a 1¼-in. stay-rod; the inner end of each was screwed into the projecting end of the pillow block of the crank disk. The other end of each rod passed through the hole in the angle iron and was made tight by a nut, as shown.

To make the job more secure, a small casting was made to fit against the outer end of the frame and pillow block. Two holes were drilled in it for two 2-in. rods which were slotted for a key as shown in Fig. 3. The other end of each rod was fastened, drilled and secured to the engine frame by a bolt which extended through the engine frame and both eyes of the two bolts, as shown just back of the crank disk in Fig. 2. The bolts drew the frame tight at the bottom and prevented end-play at that point.

This completed the job, and the engine has been in use during working hours for a period of about three years, which speaks well for the manner in which the work was performed.

Setting Valves on a Corliss Engine

By H. P. Porter.

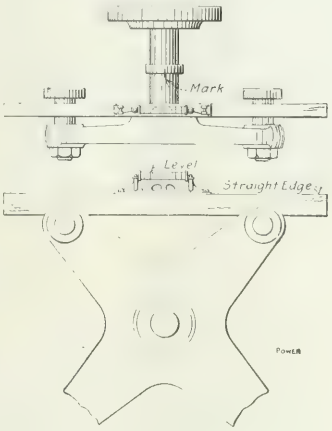
To set the valves on a simple Corliss engine of any design is not always as easy as might be supposed. While many have the principal motions of the gear fairly well in mind, and others understand it well, it is not uncommon to find a man in charge of large engines who cannot tell in a straightforward way how to go about setting the valves.

There are six principal operations to perform in setting the valves, these are as follows:—

1. To set the wristplate.
2. To adjust the valves.
3. To equalize the travel.
4. To put the engine on the center.
5. To set the eccentric.
6. To adjust the governor rods.

For example, consider any sized engine of a simple type having one cylinder. To set the wristplate, first note if there is a manufacturer's mark indicating when it is in the central position of its travel. If there is no such mark, in the case of a horizontal engine, use a straight edge and level, as in Fig. 1, bringing the steam rod pins level, then mark the wristplate so that the mark comes on both the moving part of the hub and the stationary part of the shaft or stand. In order to do this it may be found necessary to disconnect the steam rods. In the case of a vertical engine the steam-rod pins would be vertical, or in any case they would be parallel with the center line of the engine.

To adjust the valves, after the wristplate is in its central position, it is first necessary to know just how much lap the valves must have. This information should ordinarily be secured from the manufacturer although in some cases the engineer may set the valves by guesswork and later adjust them correctly with the aid of an indicator. There is quite a difference in the amount of lap of the valves for the same sized engines of different designs. The writer has in mind one manufacturer who for a 16-in. diameter cylinder sets the steam valves with $\frac{3}{8}$ in. lap and the exhaust valves with $\frac{3}{16}$ in. lap, while another manufacturer allows the steam valve $\frac{1}{8}$ in. lap for every 10 in. diameter of cylinder and sets the exhaust valves without any lap. For a 16-in. cylinder this would give the steam valves 0.2 in. lap. There are other manufacturers who would give this same engine about $\frac{7}{16}$ in. lap for the same engine and $\frac{1}{32}$ in. negative lap for the exhaust valves. This goes to show that all gears are not designed to give the same laps of the valves for the same size of engines. Again, the data given on this subject by the manufacturers is not always absolutely correct for every case; they cannot always foretell what conditions the engine may work under, and in the end, the valves should always be readjusted by means of the steam-engine indicator.



CENTERING WRISTPLATE

To equalize the travel of the wristplate, is to so adjust the eccentric and reach rods that the plate moves during one complete revolution of the engine, the same distance on either side of the center as indicated by the mark on the hub. This is accomplished by either revolving the engine or by loosening the eccentric on the shaft and revolving it around the shaft. While making this revolution, note the travel of the wristplate, and shorten or lengthen the eccentric rods as the case demands so that the plate travel is equalized. Also while making these adjustments, as well as all others of like nature, it is well to have all the bearings adjusted so that there will be no lost motion, and the revolution should be in the direction the engine is to run.

To put the engine on center, turn it over until the crosshead is nearing one end of its stroke, then stop and mark the position of the crosshead on the guides, and before moving the engine also mark some point on the rim of the flywheel on some stationary object near by. If there is no such stationary object, construct one, then continue to turn the engine until the crosshead passes the center and returns exactly to the same position as when marked; then mark the rim of the flywheel from the same point on the stationary object again. Take a pair of dividers and locate a point on the rim half way between these marks. This half-way point is then brought to the same position relative to the stationary object as were the original marks when made, and the engine is on center.

To set the eccentric, the engine must remain on center while the eccentric is revolved around the shaft in the direction it is to run, at the same time noting when the steam valve (on the end corresponding to that at which the crank is set) begins to open. When this valve has opened the necessary amount for the lead, make the eccentric fast to the engine shaft by tightening the setscrews, and also mark the eccentric for future references. For an engine having a 6-in. cylinder the lead might be $\frac{1}{32}$ to $\frac{1}{16}$ in., depending upon the speed at which the engine is to run; the greater the speed the more the lead.

To equalize the governor rods and adjust the cutoff, block up the governor to the position in which it should run at medium full load; this will on most engines be between $\frac{3}{4}$ and $1\frac{1}{4}$. Then rock the wristplate and note that the knockoff blocks disengage the hooks from the valve arms at the same point each side of the center, or turn the engine to $\frac{1}{4}$ of its stroke and adjust the rods so that they knock off the valve at this point for each stroke.

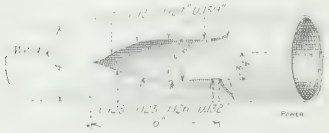
Seneca River Boiler Tube Blowout

There have been no new developments of importance regarding the fatal boiler-tube blowout on the dredge "Clyde" on Nov. 16, in which four men were killed, as reported in POWER for Nov. 28.

The "Clyde" was equipped with two Babcock & Wilcox 400-hp. marine boilers, the one which failed being located on the starboard side. The boilers were run continuously night and day under full evaporation at the time of the accident. The burst tube was one at the end of the lowest row and the fracture occurred on the underside of the tube about 6 in. from the bridge-wall. The longitudinal fracture was about 6 in. long and the traverse about 4 in. long.

The boilers, which had been in use for three years, operated at 175 lb. gage. The engines were run condensing and the condensed water was used in the boilers.

As stated in the issue of Jan. 2, the failure of the tube from an engineering standpoint, was believed to be due either to defective material or to material weakened by pitting or corrosion, or by overheating; there was nothing to show the existence of excessive pressure. This opinion was later borne out by the discovery that a slight trace of oil was observed at the water line and that it is possible that enough oil got into the boiler to allow the tube to overheat. Turkish toweling and straw filters were used.



THICKNESS OF METAL AT FRACTURE

There was no drawing down of the metal to speak of, the rent being as shown in the accompanying drawing.

Designing a Bearing

BY PROF. R. C. H. HECK

In commenting upon a poorly designed bearing in the issue of October 10, C. R. McGahey draws some inferences which a closer study and a clearer understanding of the problem show to be outside the limits of possibility. The arrangement criticized is reproduced in Fig. 1, with the addition of dimensions appropriate to an engine with the speed named, or running at 240 revolutions per minute. It was claimed that the bearing shells, instead of having only a narrow support at midlength, ought to be rigidly held in the frame of the machine; and to this supposedly insufficient rigidity of support and consequent flexure of the shaft was attributed, in one case, a vibration or "wabble" of the wheel rim, having an amplitude of $\frac{3}{16}$ inch. It is now proposed to work out definite results for the conditions represented in Fig. 1; and even though an acquaintance with the "mechanics of materials" is needed for a complete understanding of the methods used, an outline of the calculation may be of general interest.

OUTLINE OF CALCULATION

First of all, the connecting-rod pressure $P = 20{,}000$ pounds is about as heavy a load as is likely to come on a 6-inch shaft; it would be produced by an effective steam pressure of 130 pounds per square inch on a 14-inch piston or 113 pounds on one of 15 inches diameter. If this load is resisted by pressures $R\,R$ concentrated at midlength of the bearings, it would develop a maximum stress of about 6000 pounds per square inch in the crank pin or right under P, Fig. 1. In briefest outline, without any explanations, the calculation of this stress is as follows:

The shaft is considered a simple beam, 26 inches long, and with a load of 20,000 pounds at the middle. The moment of inertia of the section is

$$I = \frac{\pi d^4}{64} = \frac{3.142 \times 6^4}{64} = 63.6$$

The section modulus, with the radius 3 inches as the distance to remotest fiber, is then

$$\frac{I}{c} = 63.6 \div 3 = 21.2$$

The maximum bending moment is

$$M = \tfrac{1}{4}\,P\,l = 20{,}000 \times 6.5 = 130{,}000 \text{ inch-pounds}$$

Therefore the greatest stress is

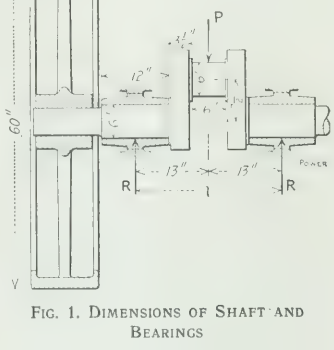


FIG. 1. DIMENSIONS OF SHAFT AND BEARINGS

$$S = 130{,}000 \div 21.2 = 6130 \text{ pounds per square inch}$$

Provided that the crank webs are of sufficient strength, the crooked form of the shaft has no influence upon stress in the crank pin; but it does help to determine the flexure under load. To allow, roughly, for bending in the crank webs, let the actual shaft be replaced by a straight round bar of the increased length (between supports), shown in Fig. 2, and with a load at the middle sufficient to produce a stress of 6000 pounds. The stress along the bar will vary from this maximum value under P to zero at the supports, in the manner represented by the shaded diagram $A\,K\,B\,A$.

STRESS

Stress is the inner force which resists the tendency of external forces to change the shape of the body; but the development of stress is accompanied by some change of shape. The bending action of the forces P, R, R, in Fig. 2, produces compression and shortening on the top side of the bar, and tension and stretch along the bottom. Change of length is proportional to the stress developed, and the ratio of stress per unit of area to elongation (or shortening) per unit of length is called the modulus of elasticity. For steel this ratio is about 30,000,000. As already noted, in this example the stress varies uniformly from 6000 pounds per square inch to zero; and the resultant effect is as if an average stress of 3000 pounds were assumed to exist along the whole bar. Dividing 3000 by 30,000,000, the length of the bar will be changed by 1 in 10,000 of its free length. Then the 32 inches at $A\,B$ will be shortened by 0.0032 inch, while at $C\,D$ there will be a stretch of 0.0032 inch. Now the lines $C\,A$ and $D\,B$, originally parallel, will approach each other at the rate of 0.0064 inch in 6 inches, or of 1 in 940. From its original position parallel to $M\,N$, either line will be deflected at half this rate, or by 1 in 1880.

Suppose that a wheel of 60 inches diameter is mounted on the shaft, as in Fig. 1. To give a 30-inch radius a deflection of 1 in 1880 would swing the outer end of it

$$30 \div 1880 = 0.016$$

or about $\frac{1}{64}$ inch, from its mean position; and with the same deflection in the opposite direction, the total range of vibration would be about $\frac{1}{32}$ inch. The load assumed in Fig. 1 is larger than would be likely to come into play in the ordinary working of the engine; and if a wheel were observed to vibrate through $\frac{3}{16}$ of an inch, it certainly was not set squarely on the shaft.

PROPER SUPPORT FOR BEARINGS

So much for the matter of probable quantitative values of stress and flexure.

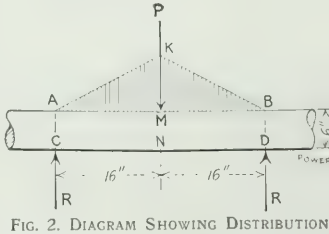


FIG. 2. DIAGRAM SHOWING DISTRIBUTION OF STRESS

Next comes the question of proper support for the bearings. The determining requirement for cool and easy running of a high-speed bearing is uniformity in distribution of pressure between the journal and the bearing. If the bearings in Fig. 1 are held rigidly and exactly parallel to the axis of rotation, and if the shaft bends under varying load (as it must), one end of the journal will be pressed harder than the other against the bearing. The fact that most engines of the class represented have full-length seatings for the boxes in the frame, and yet work satisfactorily, means simply that the shaft flexure is not large enough to cause trouble. The use of flexible support, which permits the bearing shell always to aline itself with the bearing is universal for line shafting and very

ommon in large engines and in steam rbines. The original design of the cen-r-crank engine most like Fig. 1 had herical seatings for the bearings in the ame. This is correct in principle, but as been found an unnecessary refine-ent for small engines.

Of course, if a heavy wheel is not set uarely on the shaft, the resulting vi-ation will strain the arms severely; but standard high-speed engine on the arket has a shaft light and flexible ough to permit serious vibration of this rt, due to flexure under steam force.

Cast-Iron Head Blown Out of Steam Dome

An unusual boiler explosion occurred 9:45 a.m., Monday, Jan. 9, at 98 First ve., New York City. The boiler was ft. long, 36 in. in diameter and was nstructed with a shell ⅜ in. thick and ith heads ½ in. thick. The shell metal d a tensile strength of 50,000 lb. The iler was located in the basement of orsch & Co., and was used to supply eam for heating and power purposes.

The boiler was set under the sidewalk th the top of the steam dome about in. from the arch which forms the iling of the boiler room. The rupture the boiler occurred in the cast-iron ead of the steam dome, the head being ⅝ in. thick and 30 in. in diameter. It actured at the flange and was probably own into small pieces as it cannot be und. The top of the dome was blown through the sidewalk, slightly injur-g two men, the engineer and a passer-.

The boiler was 32 years old, having een built in 1880, and underwent a 120-lb. hydrostatic test on Oct. 25, 1911. The pressure allowed on the boiler was 80 lb. In Fig. 1 is shown a partial view of the boiler setting and the steam dome; Fig. 2 shows a view of the power plant, which consisted of a steam and gas engine, a small refrigerating machine and other small units. Aside from the damage done to the boiler dome and some of the piping, the boiler was not damaged. It is doubtful, however, if it will be again put into service, as a new boiler is being installed. No blame is attached to the engineer in charge at the time.

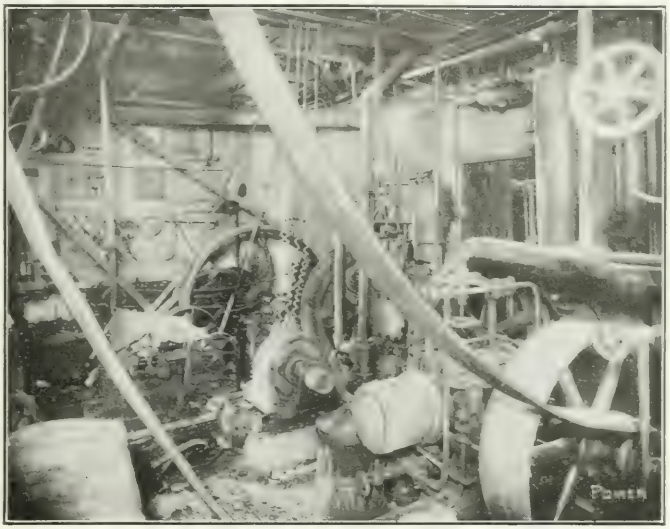


FIG. 2. HOW THE ENGINE ROOM LOOKED AFTER THE EXPLOSION

FIG. 1. BOILER UNDER SIDEWALK. CAST-IRON HEAD OF DOME WAS BLOWN UP THROUGH THE ARCH AND SIDEWALK

New York's Hydro-Electric Possibilities

Governor Dix, in his latest message to the New York Legislature, gives serious consideration to the state's hydro-electric possibilities in the following words:

New York State is unique in its possession of hydraulic energy. Surrounded by water on its entire western, northern and southern borders, there is a possibility of developing from latent energy, not at present utilized, one and a half million horsepower, which can be distributed through feeders along the line of the Erie Canal and the Champlain Canal, that will be extending through the southern tier of counties sufficient energy to create in perpetuity the power now supplied by the annual consumption of twenty million tons of coal.

It is estimated that the state's industries purchase from neighboring states an equivalent of 1½ million horsepower in coal alone; that in New York City one railway annually consumes 500,000 tons of hard coal and 150,000 tons of soft coal, and another burns 350,000 tons; steam users, 2,000,000 tons; houses, hotels, stores, etc., 1,500,000 tons, and families, 1,000,000 tons—in all, says the *Coal Trade Journal*, as nearly as can be estimated, there are 19,184,846 tons consumed annually in Greater New York.

These figures are startling, and are a strong argument in favor of the necessity of the state adopting every means of conserving its vast water-power resources.

While the state will be compelled to make heavy expenditures before its hydro-electric resources are made commercially available, their development will make New York one of the wealthiest and most prosperous states in the world.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Old Reliable Steam to the Rescue—Under Difficulties

By R. C. Turner

An occurrence which illustrates the advantage of having a steam plant to supplement water power added to the experience of the Georgia Power Co., at Atlanta, recently. This company operates two hydro-electric stations on the Chattahoochee River, one at Morgans Falls, 18 miles from Atlanta, and the other at Gainesville, Ga., 55 miles north of the same city. At the Morgans Falls plant, the equipment consists of six three-phase machines with a suitable equipment of water-cooled transformers for raising the voltage to 22,000 and the delivery of 15,000 hp. at the station switchboard. The whole output of this station is transmitted to Atlanta and sold to the Georgia Ry. & Electric Co. After going through the substation at the city limits the current is delivered to the railway company at 6600 volts. The purchaser operates all the traction cars in the city and also furnishes the street lights as well as a heavy residential and commercial load. The Gainesville plant has a rated capacity of 12,000 hp. and furnishes the cities of Gainesville, Buford and Norcross with electric lights and power.

The current coming into Atlanta from the Gainesville plant is transformed at the city limits from 50,000 to 11,000 volts, and is distributed in the city at this voltage, the service being used mostly by manufacturers.

Early in September the management of the Georgia Power Co. realized that if it did not rain in a few days the river would be so low at the Gainesville and Morgans Falls plants that it would be impossible to operate more than a few hours during the day. The Georgia Ry. & Electric Co., however, offered to render all the assistance possible with its steam plants, the Georgia Power Co. to furnish all the transformers and other apparatus needed.

The Georgia Power Co. sent six 600-kw. 11,000- to 2300-volt transformers to the Davis St. plant of the Georgia Ry. & Electric Co., and the 2300-volt feed line coming from the Georgia Ry. steam plant was connected to the corresponding terminals of the transformers, the 11,000-volt terminals being connected to a temporary line from the Davis St. plant to a substation located near-by. At the substation a spare transmission line from the Morgans Falls plant was hooked on, giving an 11,000-volt line out to the city limits. At the outer district temporary lines were run and single-pole knife switches installed and connected to the transmission line from the Gainesville plant, 50 miles away. Two miles from the temporary jumpers and switches, the line enters the North Boulevard substation for the final step-up from 11,000 to 50,000 volts, this being the voltage used between the North Boulevard station and the generating plant at Gainesville.

When everything was completed, the steam plant was notified to cut in at 10 p.m. and carry the load of the Gainesville plant from this hour until 2 p.m. the following day. At the Gainesville plant the head gates were to be closed at 10 p.m. and water stored up in order to be able to take up the load at 2 p.m. every day until it rained enough to relieve the situation.

Following out the order, engineers at the Davis St. plant at 10 p.m. threw in the switches, paralleled with the Gainesville plant and picked up the load, the Gainesville plant cutting out at 10:05. For ten minutes everything worked nicely; then three of the 600-kw. transformers at the Davis St. station went up in smoke before the attendants could cut them out of the circuit; the other transformers were cut out and the Gainesville plant had to pick up the load again.

On the following day, upon examining the remaining 600-kw. transformers, it was decided that the accident was caused by moisture, as the transformers had been out of service for several years. After making this decision, the secondary terminals were short-circuited and 220 volts sent into the primary windings to heat them up and expel the moisture. Steam-pipe coils were also employed to hurry up the job of drying them out. After a few days the transformers were subjected to a severe insulation test and put back on the line; at 10 o'clock that night the Davis St. plant again took up the load of the Gainesville plant. Everything worked perfectly for a few days; then the transformers which had been subjected to the drying-out process followed the fate of the first three and went up in smoke.

After the failure of the second bank of transformers, three spare 1500-kw. transformers at the Morgans Falls substation were connected up and worked perfectly for several nights, when one of them, carrying less than three-fourths of its rated load, followed the fate of the first ones and went out of commission. When this happened, the engineers of the company decided that they were about at the end of the rope, as the drying-out process on the remaining 600-kw. transformers was not completed and they were unwilling to run the risk of any more burnouts. However, on the date of the last burnout, word was received from the Gainesville plant that a heavy rain had fallen in that vicinity for the past 24 hours, breaking the 60-day dry spell, and that they would be able to operate the plant 24 hours per day until further notice.

LETTERS

How to Color Lamp Bulbs

In the Jan. 2 issue, Harry L. Seifts asks for a process to color lamp bulbs. There are several different methods; a simple and inexpensive one is as follows: Take some white shellac and thin it down with wood alcohol, using considerable of the alcohol to get a very thin mixture. Dissolve some ordinary powder dye, of the color desired, in some alcohol and mix it with the thinned shellac. Place the mixture in a vessel at least 6 in. deep, and immerse the bulb in it, taking care not to dip the lamp deep enough to get the base in. After dipping, the lamp should be hung vertically in a socket and the current turned on to dry it. Any depth of color desired can be secured by properly proportioning the quantity of the dye in the shellac. If necessary, the coloring can be removed from the bulb with alcohol. A good coloring liquid can be bought especially made for bulb coloring from dealers in electric goods.

James E. Noble.

Toronto, Ont.

Answering Mr. Seifts' question as to treating lamp bulbs, I offer the following suggestions:

Take a little white shellac and cut it with alcohol; dip the bulb in this mixture and let dry, when it will be a good imitation of frosted or ground glass. For coloring, take a little egg dye of the color desired and dissolve it in a little alcohol and color the shellac with it. When desired the color can be cleaned off with alcohol.

Another method is to dip the bulb in a solution of collodion, in which an aniline dye of the desired color has been dissolved. These dyes can be obtained at any drug store, and are about the same as the egg dyes. When dipping, care should be taken not to wet the base of the lamp.

EDWARD L. JOHNSON.

Brooklyn, N. Y.

Polarity of the Cooper Hewitt Lamp

In the Catechism of Electricity on page 15, Jan. 2 issue, the reference to the polarity of the Cooper Hewitt tube is evidently reversed. The letter *A* should be at the right-hand end and the letter *C* at the left-hand end of the tube in Fig. 393.

E. G. HOPPE.

Cairo, Ill.

[Mr. Hoppe is right. The letters *A* and *C* should have been transposed. The fourth line of text beneath the picture should have read: "large bulb *A* at the right-hand end of the tube" and the seventh line below the picture: "cup *C* at the left-hand end of the tube."—EDITOR.]

The Cash Value of Electrical Knowledge

The worth of electrical knowledge does not appear to be very large, to judge by the growls in the press on the matter of engineers' wages. On this side of the Atlantic, at any rate, we know how to fix the pay sheets. The following advertisement is from the *Manchester Guardian* of Nov. 21:

WANTED, in Mains, etc., Department of Electricity Supply Station, near Manchester, man to install, maintain and repair motors and make himself generally useful in the Department; one able to fix and read meters; wage to commence £1 ($4.87) per week of 50 hours, with prospect of increase for satisfactory man. Address R 62, M/c Guardian.

It is gratifying to note that a satisfactory man will have a "prospect of increase." It is, however, to be hoped that the prospect will not be so dazzling as to cause any hurt to the eyes of the prospector.

There are not many better-paid jobs than the electrician's, are there? What? Oh, yes! I'm so sorry; I forgot the art of road-sweeping. Members of this profession have attained, I believe, to the munificent salary of 25 shillings per week of 48 hours. Really, I must find an experienced road-sweeper and apprentice my young hopeful to him without delay. I hope that he will not demand an exorbitant premium.

JOHN S. LEESE.

Manchester, Eng.

Unbalanced Airgaps and Bearing Wear

Under the above heading on page 922 of the Dec. 19 issue, is an article by Mr. J. B. Clapper which leaves room for much comment. The author writes of the possible decrease in service or shutdown of a power plant for a trifling cause. I fail to see how his theory can hold good for so long as three weeks.

In most cases of unbalanced airgaps the magnetic pull has such a slight difference between the opposite polepieces that the readjustment is generally made to prevent the armature from striking the poles on the bottom. If the magnetic pull on the bottom pole were 3000 lb. it would be balanced by the pull of the opposite or top pole, which has an equal amount of magnetic pull at the same instant, thus neutralizing the effect of the bottom pole pulling downward on the armature.* The weight of the armature, shaft, flywheel and eccentrics is practically the only downward pressure imposed on the bearings

It is not mentioned in the article whether the machine had a revolving armature or a revolving field magnet, or if driven by a horizontal engine or a vertical one. In all cases it is the object of the makers to use as small an airgap as gives safe clearance of the armature core. This varies but little between large and small machines and seldom exceeds ½ in. even in large machines, while motors of 5 to 10 hp. have an airgap of $\frac{5}{64}$ to $\frac{7}{64}$ in. If a vertical cross-compound or triple-expansion engine were used and two adjacent polepieces on the top side of the frame had to have jumpers put on to cut out the burnt coils without cutting out the opposite poles on the bottom, there would be more pull on the bottom than at the top of the armature.

This, in addition to the weight of the connecting-rods, crossheads and pistons, might produce the effect described. But I fail to see how properly designed boxes with good babbitt or bronze liners could wear down in three weeks. With such rapid wear there would be such excessive heating of the bearings as to melt the babbitt before a day's run had been completed. On large machines adjusting screws are usually provided in the feet to raise or lower the field frame so as to keep the armature in the center of the pole-face circle.

The location of the field coils cut out of service would have much to do with the stability of the machine, but cutting out the bottom or top coils would not tend to cause unsteady operation. It further appears that the machine must have been operating alone on the circuit, or with the coils cut out it could not have been put in parallel without cutting out opposite coils in the same series, thus reducing the capacity of the machine about one-fourth or to 24 poles. If the opposite poles of a revolving-field machine were not jumped or cut out, the vibration might be serious and possibly cause the destruction of the machine.

I can account for such wearing of the boxes only by assuming that the engine was a vertical one with very poorly adjusted valve-gear on the crank ends. It has been known that even horizontal engines with valve-gear out of adjustment have caused pillow-block bearings to heat, and I dare say this condition had more to do with the rapid wear of bearings described by Mr. Clapper than the unbalanced airgaps. Many machines are in daily use with unbalanced airgaps.

R. A. CULTRA.

Cambridge, Mass.

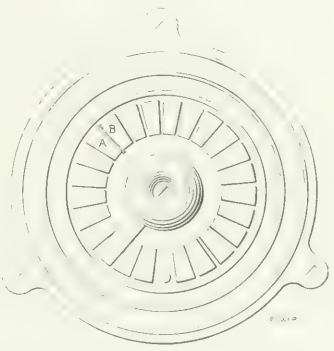
*Mr. Cultra overlooks the fact that with unbalanced airgaps the magnetic flux is not the same under all pole faces. The flux density is very much higher under the pole nearest to the armature than under the opposite pole and the difference in magnetic pull is even greater, because the pull is roughly proportional to the square of the density.—Editor.

A Quick Repair of a Rheostat

Our lights went out one cloudy day, and an examination proved the trouble to be a burned-out section in the rheostat of the dynamo.

I could not get at the wire without removing the rheostat from the switchboard, which would have taken too long, as we needed the lights badly.

I tried cutting out the resistance until



CONTACT PLATES TEMPORARILY BRIDGED

the contact finger on the revolving arm was beyond the damaged coil, but this let the voltage run too high for safety to the lamps, so I doubled a piece of 10-ampere fuse wire and drove it between the segments *A* and *B* (see accompanying sketch), to which the broken section was connected.

This temporary repair answered the purpose nicely until I could get a chance to take the rheostat down and make a new coil.

EARL PAGETT.

Coffeyville, Kan.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

A Successful Peat Gas Power Plant in Ireland

According to our British contemporary, *Engineering*, a peat-gas plant has been working in Ireland since September last, with results which are reported to be quite satisfactory. The plant is in the textile factory of H. Robb, at Portadown, and has replaced a Mond-gas plant by which power was formerly provided. The producer gasifies peat which is simply air-dried, cut from bog lands at Maghery, and stacked for the summer. As cut, the peat contains about 85 per cent. of moisture, and during an average season this can be reduced by air-drying to 26 per cent. In exceptional years, such as that experienced this last summer, peat can be dried in this district to about 19 per cent. moisture.

The plant is guaranteed to work with peat containing up to 45 per cent. moisture. It consists of two producers of 200 brake horsepower capacity each, with a coke-filled wet scrubber, a tar extractor, a sawdust scrubber, an exhauster and an expansion box. The air-dried peat is fed in block form, as cut, into a hopper above the generator, whence it falls into the generator itself as combustion proceeds. The gas is drawn off through the wet scrubber and washer to the tar extractor, where the tar is taken out by centrifugal action. It then passes on to the sawdust scrubber and is delivered to a gas holder by the fan which draws it through the producer. The gas produced has a value of about 140 B.t.u. per cubic foot.

As originally designed, the coke-filled scrubber became clogged with tar, and it was therefore modified so that the greater part of the coke was removed, and a water shower introduced, against which the gas passes upward.

The cost of the peat delivered at the works is 6s. per ton, and with an average load of 275 brake horsepower on the plant the consumption is found to be slightly under 20 tons, costing practically £6. There is a ready market for the tar at 35s. per ton, and about 5 per cent. of this byproduct is recovered from the plant, or about 1 ton per week. The net expense for fuel is £4 5s. per week. On the other hand, the anthracite used by the Mond-gas plant (8½ tons per week) cost £13 16s. 3d. The plant has not been running sufficiently long to ascertain definitely whether or not a slight increase in labor may be necessary; but allowing £40 per annum for such a contingency under these conditions at a factory of 500 looms, employing from 500 to 600 hands, a saving in the fuel bill of about £438 would result.

The operation of the plant is reported to be very simple, and after overcoming in the early stages one or two rather unexpected difficulties, of which one was due to sand becoming mixed with the peat during a long, dry summer, no further trouble has been experienced. The plant was designed and constructed by Crossley Brothers, gas-engine builders.

The Junkers Oil Engine

By F. E. Junge

Of the various internal-combustion engines which are competing with the steam turbine for preëminence in the field of large-scale economic power production and ship propulsion, the Diesel engine so far has been the only one to deserve serious consideration. Of late a new type of large oil engine is attracting attention in Germany; this is a two-stroke engine, built to the design of Prof. Junkers, of the Technische Hochschule of Aix-la-Chapelle. A freight vessel to be equipped with this type of engine has been ordered from the Weser Co., of Bremen, by the Hamburg-American Line. The power developed by the two engines is to be 1600 shaft horsepower. A 200-hp. experimental engine gave the data for the construction of a 1000-hp. engine which is now undergoing tests at Aix-la-Chapelle; Fig. 1 is a picture of this latter engine. The general arrangement of the parts of this tandem horizontal engine is shown in Fig. 2. Two pistons work in each of the tandem cylinders; the extreme forward and rear pistons act on the middle crank and the two intermediate pistons act on the outside cranks, which are set at 180 degrees from the middle crank. The connection of the pistons which move together with each other and with the crossheads is made by transverse yokes and side rods, as will appear from the longi-

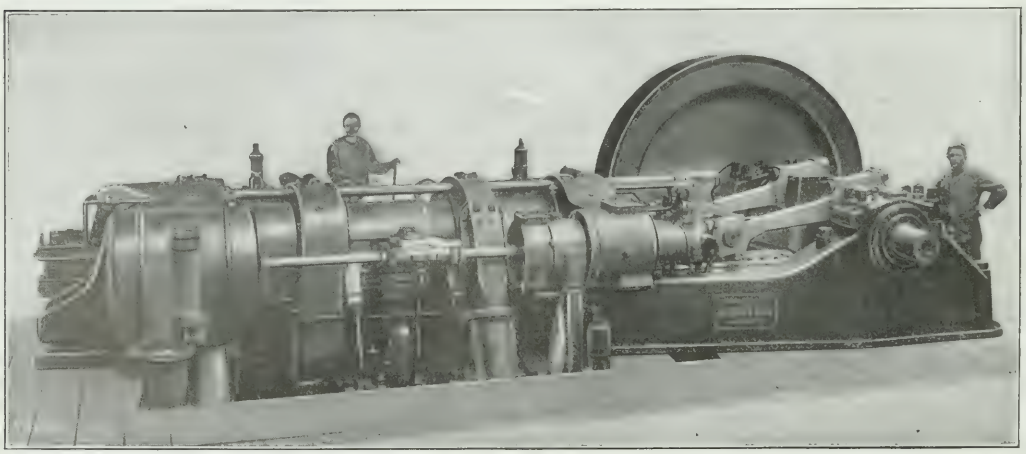


Fig. 1. Junkers High-compression Oil Engine of 1000 Horsepower

udinal section and the elevation and rom the schematic drawing, Fig. 3.

The engine works on the two-stroke ycle. While the pistons in one cylinder nove outward on the working stroke, the istons of the other cylinder travel in- vard, on the compression stroke. When he two pistons in one cylinder have eached the state of nearest approach, uel injection commences; the two pis- ons in the other cylinder have then eached the position of greatest separa- nected at the head ends. The use of stuffing-boxes is thereby avoided.

The cycle of the Junkers engine may be more clearly understood by aid of Fig. 3, in which, for the sake of simplicity, only one cylinder is shown. At the innermost position *A* of the pistons, the combustion space, after a preceding compression stroke, is filled with highly compressed and correspondingly heated air; at this moment injection of fuel is begun. The fuel is forced in by com- point *C* on the diagram, the front piston *V* begins to uncover the ports in the cylinder wall through which the burnt gases escape. In the position shown at *D*, corresponding to *D* on the diagram, equilization of the cylinder pressure with that of the atmosphere has approximately taken place. In this position the rear piston *H* uncovers the rear ports and admits fresh air at low pressure, which drives the rest of the spent gases out of the cylinder through the exhaust ports at

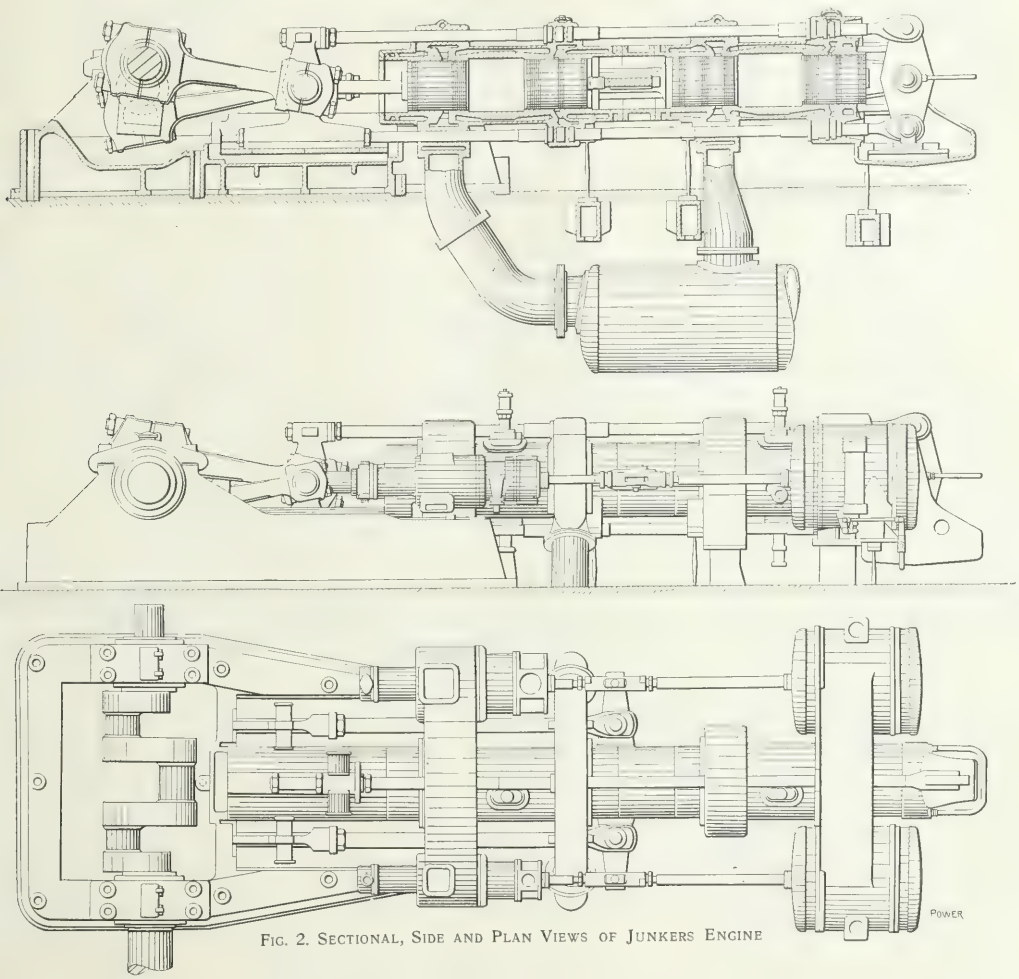


Fig. 2. Sectional, Side and Plan Views of Junkers Engine

tion, and the expulsion of the expanded gases takes place, followed by an inward flow of scavenging air through ports at the other end of the cylinder from the exhaust ports. The ports are covered and uncovered by the pistons, eliminating all valves. The ends of the cylinders are open, each cylinder being the equivalent of two single-acting cylinders with their heads removed and their barrels con- pressed air and is in a finely divided condition; it ignites and burns under almost constant pressure during the first part of the outward stroke, from *A* to *B* on the indicator diagram. During the ensuing part of the outward stroke, the expansion of the products of combustion takes place, from *B* to *C*.

When the pistons have reached the position shown at *C*, corresponding to the the front end. This process takes place while the pistons travel to the dead-center positions of the cranks and back to the position *F*, in which the pistons have closed their respective ports. At the point *F* the cylinder is filled with air alone and the compression of this begins; the inward travel of the pistons to the inner dead-center position completes the compression, giving the curve *FA* of the

iagram. The compressed air becomes eated to such an extent that the fuel rhich is injected at or shortly before oint *A* ignites, as in the Diesel engine, rhereupon the working process just de-cribed is repeated.

The air pumps and compressors (in his case four-stage) which are neces-ary for the supply of the scavenging and uel-spray air are arranged parallel to the ork cylinders and their pistons are actu-ted from the yoke of the intermediate air of power pistons. In large diame-ers each cylinder is provided with two uel sprays and one compressed-air start-ng valve. The fuel-injection nozzle is o designed as to give the fuel oil a close ontact over a large surface with the com-ustion air.

Action of Forces and Balancing

With regard to the action of forces and ue balancing of the moving parts, the

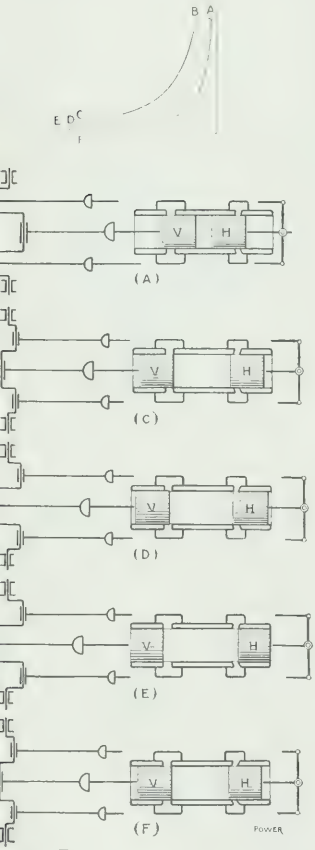


Fig. 3. Junkers Cycle

neglecting the error due to the obliquity of the connecting-rod; while the main bearings, due to the opposition of the forces in the driving elements, are relieved from thrust loads.

Owing to the division of the total stroke between two pistons, a relatively small individual piston speed is attained at a high rate of revolution and a high effective piston speed, the latter being twice the actual speed of each piston.

The general form of the Junkers engine for marine service is shown in Fig. 4. The cylinders, side-rods, etc., are arranged in exactly the same relative positions as in the horizontal engine, the only important changes being in the form of the main frame supporting the crank-shaft and the method of mounting the cylinders. It is this type which will be installed in the Hamburg-American freight vessel.

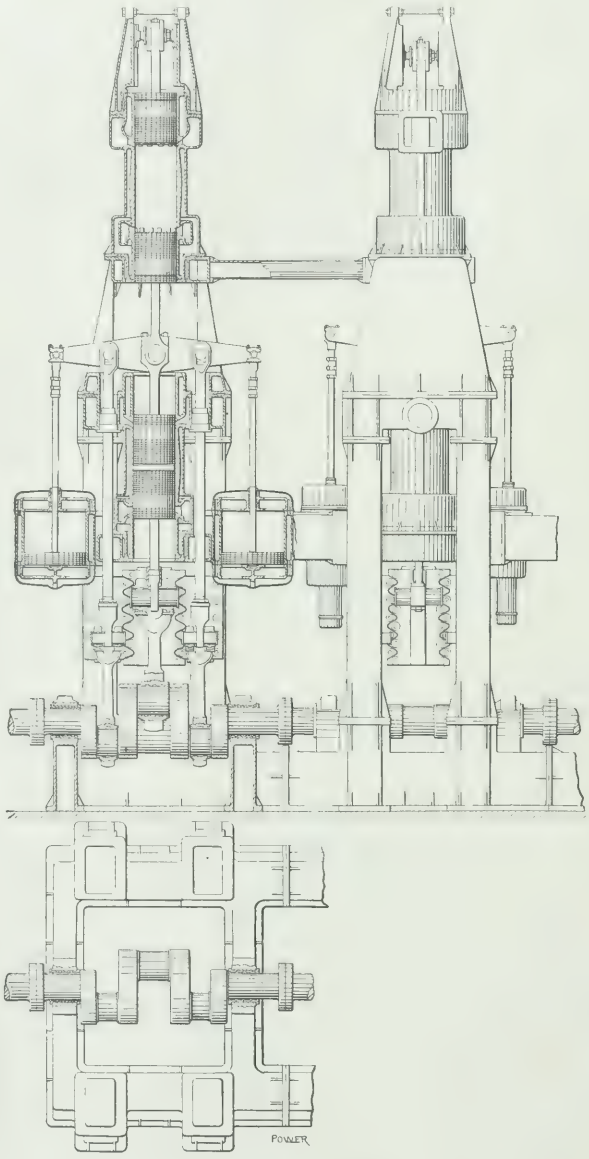


Fig. 4. Vertical Form for Marine Service

nkers engine has a decided advantage er engines of the usual type, inasmuch s the free forces are completely bal-nced in the center line of the engine,

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Charging and Starting an Absorption Plant

By Walter C. Edge

In operating a plant of this kind many things, such as the detection and stopping of leaks, the withdrawal of permanent gases, etc., are done in the same manner as with the compression machine. Installation and testing of the apparatus are done by the manufacturer and will not be enlarged upon here.

For the sake of convenience the test is hydraulic, since this form of pressure can be easily applied with the ammonia pump. Having tested the apparatus to 300 lb. pressure, it is necessary to expel the air as in the case of the compression machine.

This may be done by the process of steaming out or the raising of steam in the generator, while the connecting valves as well as a valve to the atmosphere are open. Steam passes through the system and displaces the air which is expelled at the open valve. When the steam pressure is greater than that of the atmosphere and the air has been expelled, the valve is closed and the system allowed to cool, thus condensing the steam and creating a vacuum in the apparatus. If the pump is run while the system is under steam, hot water will be circulated to the different parts of the apparatus and will have a cleansing effect. When this is done, a valve is kept open to allow the dirty water and steam to escape to the atmosphere.

One objection to this method of getting a vacuum is the fact that the heat of the steam softens the rubber packing of the ammonia joints so that they may leak and must be tightened.

It is better to use the boiler-feed pump or the ammonia pump, by which means a vacuum of about 25 in. can be created. After pumping out the air to this extent, a drum of aqua ammonia is connected to the suction line near its connection to the ammonia pump. The vacuum will cause the ammonia to flow into the system, but care should be taken to close the stop valve as soon as the liquid has been drawn out; otherwise, air will be drawn into the system. As many drums as possible are charged in this way, but as soon as the vacuum is gone the stop valve on the suction line must be closed and the ammonia pump started to force as much additional ammonia liquor into the system as is necessary.

Steam is now turned on the coils in the generator, and the ammonia is slowly heated until the gage shows about 100 lb., at which time the purge valve is opened and the discharge led into a pail of cold water until air bubbles cease to appear. Cooling water is now turned on the condenser and absorber, and, after the distributing valve to the freezing tank is opened and the weak liquor turned into the absorber, the ammonia pump may be started to pump the rich liquor through the equalizer to the analyzer.

When the air is out of the system and the expansion coils have become coated with frost, the machine is shut down and the freezing tank is filled with brine. If necessary, more ammonia may be put into the system by connecting the drum of anhydrous ammonia direct to the cooling coils and allowing the ammonia to expand direct to the system. It should be remembered that ammonia expands when heated, so that if a full charge is put into the system while cold, there will be an overcharge when everything is warmed up under working conditions.

When the cycle of operation is well under way, liquid ammonia should appear in the receiver, and any deficiency in this regard should be made up by supplying anhydrous ammonia to the system, or by adding strong aqua ammonia and withdrawing a corresponding amount of the weak liquor.

In addition to the inevitable leakage of air into the system, permanent gases may be produced by the decomposition of ammonia and from other causes. To prevent pitting of the steam coils in the generator, they should be covered with from 4 to 6 in. of ammonia liquor.

The capacity of an absorption machine is determined by the pressure in the steam coils of the generator and the amount of liquor circulated from the generator to the absorber. Pressure in the steam coils fixes the temperature, and this in turn determines the amount of ammonia distilled. With the horizontal machine and a condensing pressure of 150 lb. the steam pressure is about 50 lb. With the vertical type of machine the pressure is determined by the operator in such a way as to prevent boiling over. Leaks and the processes of boiling and siphoning over are the principal causes of trouble in absorption machines.

Poor work is detected by noting the thermometers and pressure gages, and the remedy suitable to the trouble must be applied for each particular case. Here, as in every other line of work, an ounce of prevention is worth a pound of cure, and the engineer who is on the alert to detect any unusual indications of his gages is the engineer who will have no troubles to overcome.

Properties of Ammonia

By F. B. W. Barker

Ammonia is chiefly obtained as a by-product in the distillation of coal for gas or coke. It is also obtained in the destructive distillation of organic matter containing nitrogen, such as animal matter and residues from the manufacture of beet sugar and the fermentation of molasses for alcohol. Bituminous shales and waste gases from blast furnaces are also sources from which ammonia may be extracted. Ammonia can be made from the nitrogen in the air, but the process is not economical and is therefore commercially unimportant.

The gas liquor from the hydraulic mains and scrubbers of illuminating gas plants furnishes the bulk of the ammonia used in refrigeration. The destructive distillation of coal causes the main portion of its nitrogen content to be converted into ammonia and cyanogen compounds. The chief ammonium salts which are volatile with steam are the carbonate, sulphide and sulphydrate. The other salts which are not volatile with steam are the sulphate, thiosulphate, sulphite, sulphocyanide and ferrocyanide. These salts with free ammonia are found in gas liquor.

The tar in the gas liquor is allowed to settle, and the volatile ammonia salts are driven off by heating in a still with steam, and the liquor is treated with milk of lime in another still and heated again until the ammonia is driven off the fixed salts.

The common ammonia of commerce is a solution of ammonia gas in water and its usual strength is about 26 deg. Baumé. Anhydrous ammonia is dry ammonia gas compressed to a liquid, and is manufactured by the distillation of the 26-deg. ammonia of commerce. The apparatus consists of a still, condenser, separators and a drier. The still is heated to 212 deg. by a steam coil, when the ammonia gas, with some of the water, is driven off and passes into the first separator, which usually forms an up-

d extension of the still. A greater ion of the entrained water is sep- ed from the gas in this separator by sing the gas through a series of forated plates and the water is re- ed to the still. The partly dried gas assed through a condenser, and then ugh two other separators to the r, which has perforated plates, sim- to the first separator. Upon these es are placed lumps of unslaked lime. lime absorbs any moisture which still remain in the gas, which is pumped into the shipping drums. pressure of about 30 lb. per square is maintained on the still, so that temperature may be raised a little ier than 212 deg. without causing the er to boil. In this way almost the re amount of ammonia gas is lib- ed with the least amount of moisture. ommercial 26 deg. Baumé ammonia tains 38.5 per cent. of anhydrous nonia. The latter has a molecular ght of 17 and a density of 8.5. It s at 40 deg. F. below zero at the ssure of the atmosphere.

aseous ammonia can be liquefied at ressure of 128 lb. per square inch a temperature of 70 deg. F. At a perature of 77 deg. F. the pressure t be raised to 150 lb. It is thus ap- ent that the pressure required to efy ammonia rises rapidly with the perature.

mmonia gas can be liquefied at a perature of —85.5 deg. F. At 32 F. one volume of water will absorb 9 volumes of gas and at 60 deg. F. volumes are absorbed.

mmonia gas has an injurious action copper and copper alloys, so that se metals are not used in the con- uction of any part of an ammonia em. Owing to the searching nature ammonia gas, it is very troublesome deal with, even at low pressure, and trouble is greatly exaggerated at comparatively high pressures main- ed in the compression system. The ility of leakage at the stuffing-boxes other parts of the system, is one of objections to the use of ammonia gas a refrigerating agent, particularly for rine service. It is thus by no means safe refrigerating agent, and, where d, more than ordinary precautions uld be taken to prevent accidents. is a colorless, irrespirable gas. The tant and pungent odor makes the re- rs of a part of the system confined a room or location where the ventila- n is imperfect a difficult operation. imets of leather or other material, newhat like a diver's helmet, attached a portable tank containing air under a ssure of from 60 to 100 lb., and car- d by a strap slung over the shoulder the operator, are provided in well ulated plants, to be used in an emer- ncy. As the weight of the gas is only half that of the air, it will tend to rise when escaping from a leak, so that a person who happened to be near at the time of the accident should keep as near to the floor as possible when es- caping from the premises. A person rendered unconscious by an overdose of ammonia gas should be revived by means of artificial respiration, similar to cases of drowning. Liberal quantities of vine- gar or lemon juice in water should also be given to the patient.

The chief advantages of anhydrous ammonia as a refrigerating agent are that it liquefies at a comparatively low temperature and that it has the greatest heat-absorbing power of any of the other agents.

Ammonia is combustible. When mixed with the proper proportion of air it will burn feebly, with a greenish yellow flame. If mixed with about 2.5 times its vol- ume of air it is capable of exploding with considerable violence. It is abso- lutely dangerous to insert an open flame into any part of the system after open- ing for repairs or inspection. Sufficient time should always be permitted to elapse to permit the ammonia to become dis- sipated.

The presence of permanent gases (bad gases) in the system reduces the effi- ciency of the plant, by decreasing the capacity of the condenser coil, requiring either more cooling water or a greater pressure in the condenser. Air drawn into the system through leaks, when pumping a vacuum, in the low-pressure end of the system gives the most trouble. Nitrogen and hydrogen are also formed, due to the decomposition of ammonia by excessive heating during compression. These gases are removed by opening the purge valve located at the condenser or the highest point of the system. A hose should be attached to the outlet of the valve and the end immersed in cold water. The valve should be kept open as long as air bubbles escape to the surface of the water. A crackling noise in the water indicates that am- monia is escaping and the valve should then be closed.

LETTERS

Temperature of Ammonia Discharge Pipe

I noticed in the Dec. 12 issue an arti- cle by D. E. Aden on the above subject. I agree with him that it depends on whether a dry- or wet-gas machine is used.

In a wet-gas machine the tempera- ture of the discharge pipe depends on the amount and strength of the charge and the distance that the engineer wishes to freeze back. A live charge will gather more heat from the tank per pound of liquid admitted than an old charge la- dened with aqua and oil. Thus the dis- tance of freezing back on the suction side of a machine is greater for the former than for the latter. Some ma- chine builders advocate a hot discharge and others think that it should be luke- warm. For my part, I think that the temperature should not be above 170 to 180 deg., and even this is a little high for the good of the charge.

In one plant in which I was assistant, the hot side was run luke-warm, and we got 40 tons from a 30-ton tank. In the plant in which I am now employed there is a 20-ton tank, single-pipe condensers and the temperature of the circulating water is 90 deg. We get 26 tons per day for as much as seven days, and then 24 tons for a few days more. The point that I wish to bring out is that, with a good live charge, by running the dis- charge pipe just hot enough so that I cannot hold my hand on it for over two seconds, even if the frost is crawling over the heads a little, I can get by far the best results and can hold the tank temperature better.

In the first plant mentioned the frost line had to be held back to the edge of the valves. I also found that I got a great deal of aqua or "dead juice" from this system. Could this have been caused from overheating? I would like to hear from readers of POWER on this point and would also like to know at what tempera- ture does ammonia precipitate.

BENNETT STORY.

Kingfisher, Okla.

Fire Precautions for Steel Stacks

In its statistics of fires in electric- light and power stations the National Fire Protection Association reports that six out of eighteen fires were caused by the wooden-roof construction igniting from the lack of protection from the heated steel stacks.

It is advocated that free air space should be provided entirely around a steel stack and that the stack should be protected by a steel-plate umbrella attached to it some distance above the roof opening and spreading out so as to protect it without touching the roof. A cylindrical sheet-steel ring projecting above and underneath the roof should be placed around the opening for the chimney.

A well known fire-insurance concern in Boston, which has been carrying on investigations into the causes of fire in boiler plants has suggested that fires may occur from rapid corrosion of the stacks due to condensation of the acid products of combustion near the roof line. This inside corrosion will in time provide small holes for the sparks which are usually the beginnings of fire on boiler- house roofs.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 11—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Old Boilers Are Dangerous

The two boiler explosions which have occurred recently in New York City, while resulting in no loss of life and with but slight property loss, when compared with what might have been, point out the lesson that old boilers should be discarded before they become unsafe.

Both of these boilers were old, and they were carrying as high a steam pressure as would have been considered safe several years ago.

The deteriorating action, due to long usage, gases and contraction and expansion, may have been considered to some slight extent when the boilers were inspected, but good judgment is necessary in ascertaining just how much a boiler has deteriorated and how far the deterioration should be allowed to continue before the boiler is condemned.

A boiler may become unfit for use in a few years if it has been abused; a similar boiler may be in apparently good condition at the end of twenty years. There comes a time, however, when a boiler, like an old and faithful horse, should be retired upon general principles. Just when that time comes is a question, but surely, a boiler which has been in constant use for thirty-two years has passed the age of safe operation, especially when cast iron enters into its construction.

Cast iron is a treacherous metal and utterly unfit for boiler construction, and boilers in which this metal is used should be debarred from high-pressure service.

There are doubtless many boilers of questionable age in operation in every large city which should be condemned.

It is poor practice to pass a law compelling engineers to pay for a license to operate steam boilers in order that the public shall be protected against accidents and then to permit old, decrepit boilers to be operated after they have reached a ripe old age.

The best engineer in existence cannot make a boiler thirty-two years old safe, but a boiler-inspection department can make the owners put in a new and much safer boiler. Will they do it?

Accessibility in Modern Power Plant Design

In comparing a typical, uptodate power plant with that built twenty or twenty-five years ago, one is impressed (next to the increased capacities of individual units) with the attention given to general accessibility, light and ventilation. Formerly, these requirements were considered as of very secondary importance, and the building was usually made only large enough to house the necessary apparatus. Now, however, they are considered among the prime considerations of good design.

While the concentration of large power into comparatively small-sized units and the generally recognized necessity of providing for future extension may have had some influence, still they would have been offset to some extent by the increased value of property. Therefore, one must look further to account for this tendency in present practice. Undoubtedly, it is due to a recognition that better operating results are thereby attained.

In the first place, accessibility and light permit better work being done when making repairs. How many engineers can recall the discomfort and hindrance encountered in packing a valve placed on top of a boiler, where there was scarcely any headroom and practically no light, not to mention the total absence of any ventilation; or, again, in making repairs to a pump poked away in some inconvenient corner or close to a wall?

Under such circumstances, it is impossible to expect good workmanship and the effect upon the operating force is not conducive to good results. Moreover, an excuse will often thus be furnished for letting apparatus run without the necessary attention and minor repairs until a breakdown occurs.

ain, a light plant furnishes none of dark corners which are so apt to as a convenient place for the ac- lation of rubbish. But perhaps one e greatest advantages of having all g and apparatus easily accessible is in cases of emergency the proper s, etc., may be got at with greatest and usually with least danger.

The Card Abstract

exceedingly useful and valuable which may be acquired both by eginner and by the experienced en- r as well, is the making of short acts not only of the articles appear- n the leading engineering journals lso of the material to be found in eering books. Such a habit is the rance to the reader that his reading ot superficial. We read our engi- ng journals in order that we may up to date; but too often our read- s a mere skimming, a habit which have unfortunately contracted in ng our Sunday newspapers.

ere is scarcely a person interested ny way in mechanical engineering does not have his hobbies. These be related to the work which he is every day or they may be a side . For instance, many steam engi- s, while endeavoring to keep in touch subjects related to steam engineer- are also very much interested in engineering. The short abstract of- such a man a method of collecting different sources information along various lines and compiling it into ore or less harmonious whole.

e short abstract has the advantage the filing of clippings in several ects. In the first place the journal which the abstract is taken is not lated. In the second place, inasmuch clipping may be filed without more merely reading the heading, the ract, since it requires a careful and nilative reading, is in most cases h more likely to make a lasting and able impression. In the third place not necessary when consulting the ract to read through the whole mass he article in question as only the ntial points are recorded.

ne card abstract is mentioned because s are a very convenient and effective ns of collecting and filing such information. They are inexpensive, several hundred cards costing only a few cents. The filing box of cardboard may be purchased for a very small sum while, of course, more elaborate ones may be had. The card collection is very flexible and cards may be added or removed practically without limit. The cards are portable and enough cards for several hours' work may easily be carried in an envelope. The loose-leaf notebook possesses many of the same advantages which the card collection has. However, it is usually a little more expensive and is not quite so flexible in that it is limited as to size.

The first step in abstracting a paper is to note down the title and the location of the article so that reference may be had to the original if it should become desirable or necessary. The author's name, the date, the page and the name of the journal should all be carefully noted. Especial care should be taken in abstracting an article to be concise and yet thorough. The purpose of the abstract should be kept clearly in view from the beginning. An abstract is usually made so that the information which the original article contained may be put into a more convenient and usable form.

In abstracting most mathematical studies it will not be found necessary to abstract the whole of the argument. Care should be taken that the mathematical discussion is thoroughly understood and that the conditions of the application are quite clear; then only the results need be recorded.

An abstract is not necessarily a copy. Most technical articles as written contain a large amount of descriptive and explanatory matter which may be dispensed with after the first reading. The meat of a whole paragraph may often be expressed in a very few words. In order that this may be done intelligently, it is apparent that a complete and exact understanding of the subject matter is essential. It does not require much intelligence to copy, but an abstract cannot well be made without a process of careful thinking. When experimental results or empirical data of any form are given the only way to record them in the abstract is to copy them, but in no other case is copying justified.

A series of these abstracts upon related subjects will be a valuable personal possession. Not only are the abstracts themselves useful but the vision acquired in making them is a valuable and lasting asset.

Running a Steam Turbine

In the Dec. 26 issue of POWER there was offered a prize of fifty dollars in gold to the man who, before Mar. 1, submits the best practical article treating of the above subject.

Most of the available literature on the steam turbine deals with principles, type differences, efficiencies, etc. What is needed by the stationary engineer is a working knowledge of the functions of a steam turbine, how to make it run and how to keep it running.

That the turbine is in the field to stay is evidenced by the fact that three manufacturers in this country have put out some five million kilowatts, the bulk of this in the past six years. In England alone, 6½ million horsepower has been made, nearly two million of which belonged to the period 1910-11, according to the recent statement of a well known English concern.

Responses to our invitation have begun to come in, but we want more of them.

It requires no literary training, no command of classic style or wide vocabulary to place on paper a clear, brief story of how a practical engineer should run a steam turbine. Just get the ideas into it and we will furnish the style.

Do not be deterred either from illustrating your article because of the difficulty of making the drawings; a rough sketch—such as you would draw if you were describing the apparatus or process to another engineer—will suffice; anything that our artist can interpret.

The article must be in our office before Mar. 1, and for equal merit priority in time will count.

Is New York City about to undergo an epidemic of boiler explosions? Two recent explosions have occurred in which the boilers were old enough to have been retired.

There will be some humidity in the atmosphere around the Delray station of the Detroit Edison Company if a tube splits in one of those 2365-horsepower boilers.

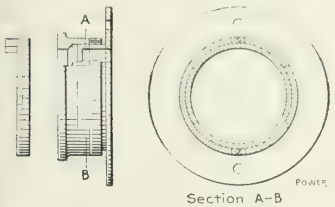
If for no other purpose than to indicate when to clean fires, draft gages are good things to have attached to the boilers.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Stuffing Box Repair

We have a duplex, outside-packed feed pump with a cavity in the stuffing-box shell as shown. What this is for I do not know, but I do know that it is difficult to get the packing in past it, and impossible to keep it there any great length of time. The stuffing-box is very short and in order to improve it I sawed out a mold and poured babbitt metal, making a ring with a projection



How Stuffing Box Was Repaired

as shown in the two views on the left. I put this ring in for an extension of the stuffing-box, the projection on the ring filling the cavity in the stuffing-box. I have no more trouble putting or keeping the packing in.

I made the rings in two pieces so I could put them in without taking out the plungers.

F. W. Bair.

Hancock, Mich.

Clearing a Fouled Feed Line

I was hurriedly called out one night by the night engineer in our plant; as he could not get any water into the boiler. The feed pump seemed to be working all right but it was injecting no water. Our feed water is just as hot as the pump will handle it. I tried the injector, but it would not work, and as it fed through the same pipe as the pump, I concluded that there was some obstruction in the feed pipe between the pump and the boiler. On taking off the head of the water end of the pump I found that the packing was all gone. I then knew what was in the heater and feed pipes.

The night engineer started to put in new packing and I began to think out some way in which to get the old packing out. I first broke a joint in the pipe next to the pump. Then I went on top of the boiler and shut the stop valve on the feed line, hoping it would be tight. Next I took the cap of the check valve off, took out the valve, put the cap on again and then opened the stop valve. Luck was with me, for nearly a peck of chewed-up packing was blown out of the pipe.

I put the check back, made up the joint that had been broken, and by that time the pump was repacked. When it was started it worked all right. It took us just 30 minutes to get running again. Since then I have put in packing that cannot be harmed by hot water.

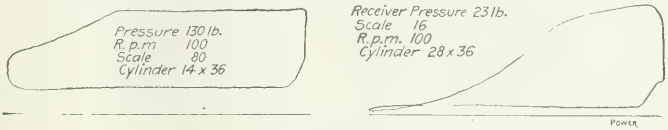
An ice plant not far from ours had the same trouble, and they were two days cleaning out the pipes and heater.

Frank H. Cordner.

Bradford, R. I.

Engine Load Not Equalized

The accompanying diagrams were taken from a 14 and 28 by 36-in. engine which has just had the valve seats bored out and new valves supplied. The engine is noncondensing.



Diagrams Showing Unequal Load

I cannot get the cylinders to take the load equally. I would like to have Power readers tell me what changes are to be made in the valve setting, and what causes the hook on the low-pressure diagram.

Harry H. Gordon.

Amsterdam, N. Y.

Copper Crosshead Shoes

Engineers often find that the crosshead shoes wear very fast under some conditions. For the benefit of any who have that trouble and who seek a remedy, I would advise using a copper shoe in place of the babbitt.

The first time I saw a copper shoe was when I took charge of a new plant of several engines, all of which were fitted with copper shoes. I expected to have trouble with them, but I found they prevented trouble. After the plant was running about six months, I installed another engine, alongside one that was running, and in putting in the concrete foundation some of the concrete got onto the guide, and fire was flying in all directions, but by putting on a liberal supply of oil the guide was soon cooled and no damage was done to the shoe; I did not even stop the engine. If this had been a babbitt shoe it would have been ruined.

C. L. Johnson.

Newark, N. J.

Illustrating Need of License and Inspection Laws

There is an old saying that a special Providence watches over greenhorn sailors and drunken men. To this I should like to add, "and men in charge of steam boilers." Occasionally we hear of a boiler bursting with disastrous effects on men and property, but this I do not suppose is due to any lack of vigilance on the part of the aforesaid Providence so much as to the extreme limit of endurance to which He must be put most of the time.

The above remarks are made not through any malice, but because contact with the outlandish conditions met with in plants in some sections of the country while acting in the capacity of boiler inspector clearly indicates the necessity of regulation by law. This necessity is made apparent by the following, which describes rather extreme conditions I will admit, but which goes to show to some extent the possibilities that exist.

I visited the city pumping plant of a small municipality not long since, being interested in such plants. Here I found an old negro in the capacity of chief engineer. His boiler plant consisted of two locomotive-type boilers. A 3-inch header connected the domes of both with one lever safety valve. There was a stop valve between each dome and the safety valve. For some reason or other, probably because of the leaky condition of the safety valve, a piece of 2x4-inch pine was tightly wedged between the end of the lever and a rafter, thereby putting the valve out of business.

No gage cock or water glass was in evidence. The only information as to the hight of the water was furnished by two leaky brace rivets in the head which were blowing constantly. When I asked

how much steam he carried, the darky replied with the enthusiastic manner of the average colored "chief engineer:"

"When de clock han' gits straight up and down, why den I opens de doo', an' ef hit sots dar too long, boss, I keeps dis heah barrel of watah close by so dat hit will be handy, an' I puts some on de fiah."

If such conditions do not call for regulation by law and competent supervision, I am willing to quit.

H. Clark.

Punxsutawney, Penn.

A Nonleaking Blowoff

To prevent a leaking blowoff I put a globe valve next to the boiler and then a gate valve. When not in use, both are closed.

When blowing down the water in the boiler, the gate valve is opened wide; then the globe valve slowly; the gate valve is then slowly closed, after which the globe valve is closed. Then the gate valve is opened to let out what scale and water remains between them. The gate valve is then shut tight.

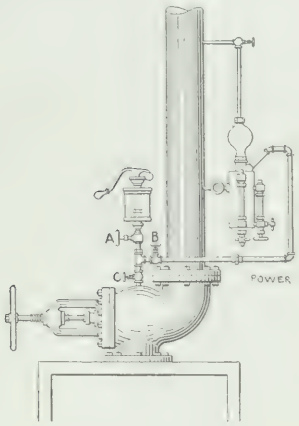
By this method there never is any small scale caught under the disk of the globe valve, and a leaky blowoff is unknown.

O. B. Hale.

Warren, Ohio.

Oil Pump and Lubricator Filler

In the accompanying sketch is shown a method of using a common cylinder-lubricating pump either as a lubricator filler or a cylinder-oil pump.



Pump and Lubricator

The pump is mounted on a tee with the side outlet piped to the filling hole in the lubricator, while the run leads to the cylinder. When it is desired to fill the lubricator the valves *A* and *B* are opened and the oil is pumped directly to it, the water in the body and condensing chamber being let out through the drain cock, while by closing *B* and opening *C*, oil may be pumped directly to the cylinder.

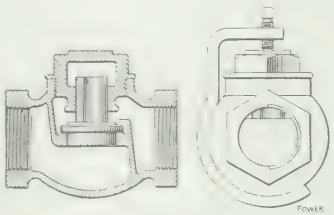
Martin McGerry.

Holley, N. Y.

Quick Check Valve Repair

In one of the plants under my care a little trouble with a check valve on a line of water pipe made quick action necessary.

The cap which acted as the stop for the valve itself was not tight, and in



Valve and Clamp

endeavoring to make it so the thread was stripped. There was no time just then to put in a new valve, so it was fixed up very simply, and at the same time effectively, as shown in the sketches. A clamp, which was made of ⅜x¾-inch iron, with a ⅜-inch setscrew, was put around the valve. With a gasket under the cap the pressure from the screw held the joint tight until the valve was replaced about a year later.

H. W. Hankin.

Troy, N. Y.

Reduced Angular Advance

The accompanying indicator diagram was taken from a 14x36-inch engine, running 120 revolutions per minute. This engine had a pound that occurred when the crankpin was about 13 degrees below the head-end center, which I was unable to get rid of by taking up on the

From a Quietly Running Engine

bearings and boxes, so, just as an experiment, I decreased the angle of advance and the knock disappeared as if by magic. If I increase the lead or the compression the pound will appear, so I have practically cut out the compression; it will be seen that the admission line leans inward a little.

The engine runs quietly at all loads, and will carry a heavier load than before, because the decreased angle of advance makes a later cutoff possible. This is a good thing, as the engine carries a very heavy load all of the time.

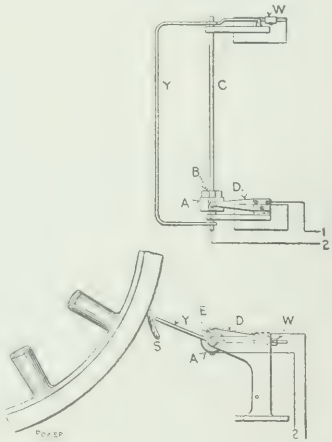
George Dreyer.

Gibsonburg, Ohio.

Rope Drive Safety Alarm

In a plant I recently visited there were three rope drives, one from the engine to a jackshaft and one from the jack to either side to two line shafts. The drives were of the American type and had been in continuous operation for seven years without a break.

The one man in the plant had to be in the boiler room most of the time. The engine and boiler rooms were about 30 ft. apart with a room between them, and through fear of the ropes breaking while he was away, the engineer rigged up an alarm device. The arrangement is shown in the accompanying sketch.



Details of the Alarm

A wooden piece *B* is put on the axis *C* and the brass piece *A* forced over this wooden piece, making *A* insulated. The piece *A* has a piece of wood *E* inserted in the circumference; and *A* is put on the axis in such a way that the spring *D* comes in contact with *E* when the arm *Y* is in its normal position. This keeps the circuit open. One wire of the circuit, No. 1, is attached to the spring *D*, and the other, No. 2, is attached to the insulated strip *A*. The arm *Y* is counterbalanced by the weight *W*, making it easy to throw back. The current is supplied by four dry batteries, and two 6-in. gongs, one in the engine and one in the boiler room, are inserted in the circuit for the alarm.

When the rope breaks, the loose strand *S* hits the arm *Y*, throwing it back and

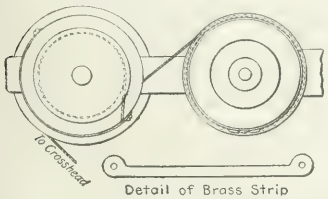
closing the circuit, by turning *A* around so that the spring *D* comes in contact with it and rings the bell.

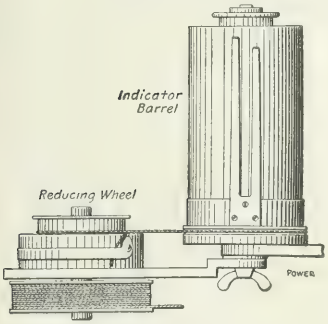
EARL L. LYON.

Oakland, Calif.

Reducing Wheel Cord Fastener

In some of the older types of indicator-reducing wheels an improvement may be made in the cord fastening by the use of a thin piece of sheet brass secured to





CORD-FASTENING ARRANGEMENT

the spring barrel by the regular cord-fastening screws, as shown in the sketch. In use the free end of the drum cord is passed between the strip and the barrel, close to one of the screws, which is tightened when the cord length is adjusted, the friction holding it securely.

This provides a quick and accurate method of getting the right drum-cord length and is especially convenient when very long diagrams are wanted, as the drum travel can be readily equalized between the stops.

A. H. BULLARD.

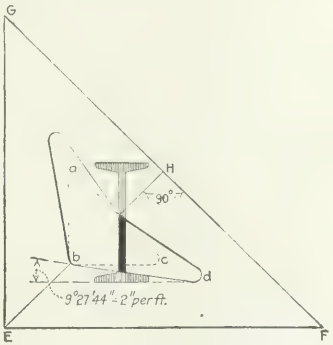
Syracuse, N. Y.

Improved Drawing Triangle

Draftsmen's triangles, as usually constructed, have a center hole or opening with edges that are parallel to the outside working edges, as shown in the sketch by the dotted lines *a b c*. This center opening is of no practical use other than perhaps to facilitate picking up the triangle from the drawing board.

Several years ago I had occasion to draw a number of sections of I-beams and channels and conceived the idea of making the inner opening of the triangle with edges having a slope of 2 inches per foot with respect to the outside edges so that use could be made of the inner edges when drawing the "shapes" just referred to.

Any draftsman, by using a little care, can cut his triangle to conform with the shape as shown. The time so spent will be repaid many times in the course of a year's work.



TRIANGLE FOR DRAWING STRUCTURAL SHAPES

Mention might also be made of the usefulness of a line, as *E H*, cut into one side of the transparent celluloid triangle. Such a line will be found useful and convenient in drawing lines at right angles to each other in sketch work when no tee-square is used.

JAMES DOW.

Syracuse, N. Y.

Wanted: Engineer of Pleasant Disposition

The following ad appeared in a "Want" column of a Detroit evening paper:

"A competent engineer who is also a good fireman and of pleasant disposition. Address, O, box 5, News."

If one reads between the lines, he will find something like this: "Wanted, a handy man with an engineer's license who has not backbone or brains enough to stand up for his rights, but will smilingly trot along and do any old job the boss asks of him, and then run back and ask for more."

I have no doubt but that someone will go and take this job, for there is plenty of this type of engineer; it is this type that is keeping the engineers where they are in the eyes of the majority of employers. They do not know their business as engineers; consequently they cannot explain their duties to their employer and their responsibility in the engine room, and what a slight neglect on their part might cause. They do not get time to sit down and figure out ways and means of reducing the cost of power, or even to examine the equipment in their charge and keep it in decent working order.

It is in the plants of such men that one will find a tin pail hanging over the main bearing with a hole punched in the bottom and a stream of water running on the bearing, oil all over the floor, dirt all over the engine, and both all over the engineer. As a rule, it is this class of engineer who always kicks about the boiler inspector being too strict.

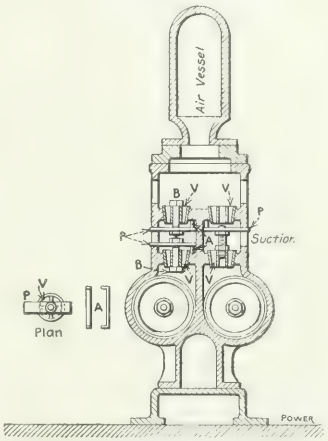
J. R. MORTON.

Detroit, Mich.

Removing Pump Valve Seats

Two months ago I was given the job of taking the bearing on the suction and delivery valves off a feed pump. The bearing surfaces on the valves were so poor that it was necessary to remove the seats and true them up on the lathe.

It was a difficult thing to remove the seats, as will be seen from the accompanying sketch. I used the device shown. I had a horse made like that shown at *A;* placed it on the farther side of the valve box and across it placed a plate *P* with a hole in the center, as shown in



DETAILS AND APPLICATION OF DEVICE FOR REMOVING VALVE SEATS

the plan at the left of the sketch, and through the center of the valve seat *V* and the plate passed a bolt *B* and tightened it on the other side, as shown in the lower part of the left side of the sketch. By this means the seats were easily removed. The method used in fixing the seats is also shown in the sketch. The left top shows the way of fixing the top seats and the right bottom shows the way of fixing the lower ones.

G. B. JOSHI.

Poona City, India.

The high, level cable railway used at the Long Island City, N. Y., power station coal-handling plant runs from the hoisting tower on the dock, through the top of the boiler house, over the coal pocket, at an elevation of 170 ft. above the dock level. It has a capacity for 400 long tons of run-of-mine bituminous coal in five working hours.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Transmitting Capacities of Pulleys

I have read with interest Lawrence Whitcomb's letter on "Transmitting Capacities of Pulleys," in the Dec. 5 issue. I do not concede the point that the comparative results of the tests under discussion are novel and contradictory to the experience of other investigators or operators. Quite to the contrary, they confirm previous tests made at Cornell University in so far as comparisons were made on like pulleys. They also conform to the conclusions drawn by at least one extensive mill operator and by another concern which purchases pulleys in large numbers, as to the relative merits of cork inserts. In fact, it was brought out in the discussion of the paper before the National Association of Cotton Manufacturers that in comparative tests made for Mr. Whitcomb, a fiber pulley gave results which point to the results of this particular test were not included in his published report.

In the very nature of the case, it is easy for a casual observer to be deceived in the relative merits of pulleys, since, as was pointed out in the original paper, pulleys having cork inserts have a large carrying capacity, although this is attended with a large amount of slip. A large slip means, of course, low efficiency, but this is not the worst feature because it also means an unsteady speed with variations in load.

With respect to the length of the cork projection above the face of the pulley, it seems absurd to lay any considerable stress upon this point, since in all cases the lengths were reasonable and two lengths of cork projection were tried for each pulley. The first test was with the corks as they came from the factory, and the second with the corks sandpapered down to as near $\frac{1}{64}$-in. as could be judged. Considerable care was taken in each case to get the exact projection, and this was recorded for the information of those desiring to study the effect of different cork lengths. If it were true that slight changes in the cork projection materially affected the transmitting capacity of the pulley, this would be a strong argument against the use of corks.

The initial tension of approximately 170 (actually 168.8) lb. per square inch of cross-section was chosen as a basis for comparison of the different pulleys because it is believed to approximate average practice. In the experiments of F. W. Taylor, reported in the *Transactions* (1894) of the American Society of Mechanical Engineers, the initial tensions in all oak-tanned leather belts was from 192 to 229 lb. per square inch. In view of the fact that Mr. Taylor is one of the strongest advocates of low belt tensions, the contention that 170 lb. is excessive does not seem reasonable.

If Mr. Whitcomb will refer to the complete report covering the entire set of tests, which is in the hands of the secretary of the National Association of Cotton Manufacturers, he will find that a comparison based on 37.5 lb. per square inch initial tension will be even less favorable to cork-insert pulleys than when based on 170 lb. per square inch.

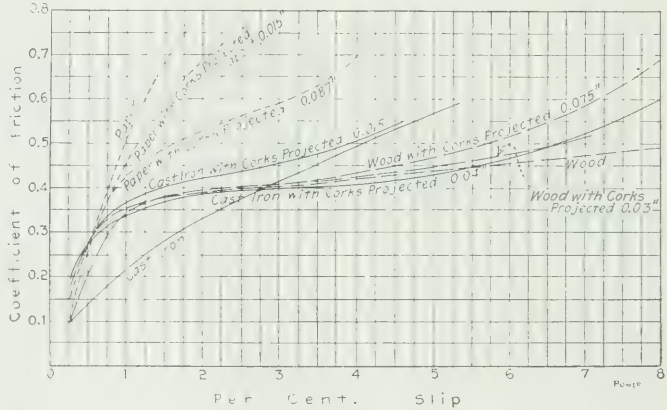
It is to be regretted that the figure used in the abstract of the original paper, which appeared in the Oct. 17 issue of POWER, page 582, is a set of curves for comparing the power transmitted per inch width of belt with the several pulleys, instead of a comparison of the coefficient of friction as denominated.

The figure which should have been used is shown herewith.

It will be noted that these figures are very similar, so that the cuts were easily interchanged. The vertical axis of the figure on page 582 should be "horsepower transmitted per inch of belt width," instead of "coefficient of friction."

The tests were all made under the same conditions, and therefore it does not appear that any injustice could be done any pulley. It is not to be presumed that it is necessary to make tests of all the different pulleys under all the different conditions of installation in order to determine which pulley to use with a given length of belt, given arc of contact, given diameter of pulley and a given speed.

It is not apparent just what "maximum figures" Mr. Whitcomb has in mind in speaking of Table 1. Referring to the figure on page 582 of the Oct. 17 issue, and bearing in mind that the vertical axis is horsepower transmitted per inch of belt width instead of coefficient of friction, and that the vertical axis is horsepower transmitted per inch of belt width instead of coefficient of fric-



VARIATION OF COEFFICIENT OF FRICTION WITH SLIP

tion, it will be seen that at 2 per cent. slip the paper pulleys carried 5½ hp. per inch width of belt, that the paper pulleys with corks projecting 0.015 in. above the surface carried 5½ hp. per inch width at 2.7 per cent. slip, while none of the other pulleys carried this load until the slip had reached 4½ per cent. or more. In view of this fact, it is not clear what "maximum figures" Mr. Whitcomb would like shown.

The criticism of Table 2 seems to be due to a lack of comprehension of its purpose. In order to make a fair comparison, it is necessary to reduce the things being compared to like conditions. It was pointed out by the author that a comparison such as made in Table 1 is not fair in that the stresses in the belt and the arcs of contact are not all the same. This is due to the very fact that the loads carried by the different pulleys at a given

slip are not the same. For example, referring again to page 582, it will be seen from Table 1 that at 2 per cent. slip the paper pulleys were carrying a load of 5.46 hp. per inch of belt width, while the cast-iron pulleys were carrying but 2.16 hp. per inch width. This means that the stress in the belt in the case of the paper pulleys is large in comparison with that for the cast-iron pulleys for this particular slip. For the same reason, the arcs of contact are different.

In Table 2, the results were computed for the several pulleys reduced to identical conditions of belt stress and arc of contact and at the same time using all the other factors as they were obtained from the data of the tests.

The belt stress of 250 lb. per square inch was chosen because it is, in round numbers, the average stress actually obtained with the cast-iron pulleys from minimum to maximum loads. This may have been confounded with initial tension by Mr. Whitcomb. In any event, reference to any of the standard handbooks, as, for instance, Kent's, will show that it is not excessive. Furthermore, an inspection of the formula used (Nagle's) will show that the results in a comparative way would not be affected whatever by the value used for belt stress.

W. M. SAWDON.

Ithaca, N. Y.

Sand for Hot Boxes

I have been following the discussion on "Sand for Hot Boxes" with much interest, and waiting for someone to tell readers of POWER the why of it all.

The term, sand, can be understood to mean any degree of coarseness. No doubt some of the writers have taken up the discussion on the assumption that the coarser grades of sand were meant, which, in my mind, is all wrong. The grade to use, if any is used at all, is the grade that would be given off by a grindstone or finer still if obtainable.

Every engineer knows that sand or any other gritty material will not cool a hot bearing but will make it hotter.

When sand cures a hot bearing it only takes away the cause of the heating, which may be either a poorly aligned bearing or one that is high in spots. Sand or any other fine, gritty substance will grind away the high places and allow the shaft to bear on the total area; the load being distributed evenly, the friction per square inch is reduced and the heat diminishes.

I once had an experience with sand in a troublesome main bearing of a pumping engine. Sand in this case was not intentional. One night the oiler informed me that the bearing was giving him trouble. After an examination, I concluded the bearing was not too hot for the water cure, and so I ordered the hose connected to the discharge pipe of the main pump, and a slight stream run in the bearing. To my surprise the bearing got hotter and hotter. I took the water off and put my hand down through a hole in the cap and on the shaft. I found the shaft to be covered with grit or sand which had been entrained in the water.

The bearing was washed out with oil, and, after all the sand had been removed, the bearing became cool.

This was my first experience with grinding; although unintentional, it was nevertheless an impressive lesson. I recommend the judicious use of fine grit for chronic hot bearings.

H. R. BLESSING.

Philadelphia, Penn.

Believe me, there is some class to Brother Freer, especially when he uses sand to reduce a hot bearing. If he ever used sand for this purpose on my ship I would make him "walk the plank."

What he saw used was brick-dust, not sand. Brick-dust is a clay and will form an enamel over a shaft or pin, while sand will score the pin and brasses.

ROBERT F. PETRASEK.

New York City.

I laughed when I read the recent article by Mr. Sprague about using sand or grindstone dust in bearings.

From experience I find that lard or sperm oil is the best lubricant for a hot box or bearing. If possible, clean the box before using the oil. I prefer the pure lard oil. A little graphite may be used, but not much as it gums, cakes and fills the oil holes and grooves. I remember on two occasions, with one large and one small gas engine, the crankpin would heat when the load was applied. I emptied out the red engine oil we had been using and put in the pure lard oil, and found that I used no more than the other oil, and had no more trouble.

Should the bearings or boxes be scratched or cut, never allow grit to get in, because the grit will embed itself in the softer metal, whether it be the box or shaft, usually the box, and heat the other and wear it out. If the box is not too badly cut, or pinches the pin or shaft, use a fine file and scraper.

GEORGE R. RITTENHOUSE.

Baltimore, Md.

In a case within my experience sand was put into a bearing to cause a hot box rather than to cure one. A generous handful was put in through the handhole in the pillow (top) block some time in the night while the engine was stopped.

I discovered the sand, however, before the engine was started. I took the cap and top shell off and wiped out as much sand as possible. Then, I turned the engine very slowly and put lots of oil on the shaft and kept wiping it off. I then put on the top shell and cap, started the engine slowly, and had a man pour oil into the bearing as fast as he could. I then brought the engine slowly up to speed, all the time keeping the bearing flooded with oil. I ran it this way for about half an hour and then I cut the oil down to about twice the regular feed. Finally, in a couple of hours the oil was reduced to the regular feed, and I had no trouble with the bearing.

I would have used a hose to flush the bearing out if I had had a water connection handy, but I did not.

I cannot see why it is any worse to put very fine sand into a bearing than it is to use lots of the other things that are employed to grind a bearing in, but one must be sure to wash it all out after it has ground off the high places.

SAMUEL H. WINTERBOTTOM.

Woonsocket, R. I.

The administration of sand to a tight bearing may be likened, in some respects, to the administration of drugs to the human being. Either is only likely to produce satisfactory results when the practitioner handling the case is an embodiment of the late Prof. Huxley's definition of science: it is "applied common sense."

Just as all drugs exercise a destructive effect on some state of the animal makeup, so do all abrasives exercise destructive effects, when forcibly applied, to the surfaces of metals in motion. But destructive disintegration of a part is often necessary in order to enhance the value of the remainder. This is particularly the case in the preparation of the different parts which go to compose a mechanism. The operations of chipping, planing, turning, grinding, lapping and polishing are all more or less destructive, but when successively performed by a skilled mechanic, they result in the conversion of a few rough forgings and castings into something which is a triumph of the metal worker's art. But had any of those pieces of metal been put into the hands of a novice, at any one of these different stages, the result would have been crude indeed.

So it is with the application of sand for the purpose of curing a tight bearing—the final result is dependent on the human equation. Sand, in the hands of an "applied-common-sense" engineer, can be made to perform good service in treating a tight bearing. Try the following: Use a grade of sand which common sense will dictate as being suited to the metals in contact, and be careful to run at a slow speed. When the bearing is sufficiently run down, wash away all traces of sand and polish up the journal with "oil and tripoli powder,"

reasing the speed slightly. Then wash ay all traces of the "tripoli," dry out, d a little flake graphite to the first se of lubricant, run steadily for half hour, then "let her go."

I have tried the foregoing with good sults, and have also experienced the uble caused by the unauthorized ad- ssion of grit to a healthy bearing. Sand in the engine room may be ened in its effects to whiskey in the me. A medicinal dose of the latter ded to grandpa's gruel will loosen up e old gentleman's tight bearings and se his load, while the same dose im- bed by grandson, in whose veins the ood is "racing" with the energy of outh, will give him such a bad attack "hot box" that the result will be —l.

ROY REDDIE.

New Market, Tenn.

Took Gases from the Uptake

Mr. Breckenridge, whose letter under ie above title appeared in the Dec. 12 ssue, is laboring under a delusion if he elieves that he can secure greater econ- my by taking gases from the flue and eturning them to the ashpit in order to ecover heat that would ordinarily go p the stack. The reason is well known o most men interested in boiler work, ut an explanation of the principles of ombustion in this case might be profit- ible to some people.

The active agent in air is oxygen. Air contains a little over 20 per cent. by volume of this gas. When coal is burned, the carbon of the coal combines with the oxygen of the air and makes an equivalent volume of a gas called car- bon dioxide, commonly represented by the formula CO_2. This gas will not burn, neither will it support combustion. In fact, if poured on a fire, it will ex- tinguish it just like so much water. The remaining 80 per cent. of the air is a gas called nitrogen, which is similar to CO_2 in that it neither burns nor supports combustion. Now, in practice it is im- possible to use up all the oxygen in the air, as if an attempt is made to do so there will be such a large amount of combustible gases go up the stack that the losses of fuel will be enormous. When gases are returned to the furnace the result would be the same as at- tempting to use all the oxygen at one burning. Large amounts of carbon monoxide would be produced and, in ad- dition, the oxygen content of the gas would soon get so low that the fire would be smothered.

The only way to recover waste heat from the flue gases is to install some form of economizer, of which there are several designs on the market. If it is desired to preheat the air before using in the boiler, the best way would be to install an air heater of some form. In the sketch shown, if the stove pipe be extended through the flue to the air and kept tight inside the flue so that nothing but pure air can get to the fire, then some economy might be effected. However, the economy effected by heat- ing the air might be offset by troubles with clinkers or by the grates burning out; this idea of preheating the air was dropped long ago for these and similar reasons.

The reason why an increase in the evaporation resulted was, in my opinion, because the ashpit was closed up, thus choking off the air supply and thereby getting nearer the right amount of air into the furnace. The steam blower also makes a kind of forced draft. In fact, on examining the sketch carefully, it seems to me that very little gas would be sucked down from the uptake, as the draft is strongest at this point and it would be much easier to suck in air through the annular space around the blower. It would be interesting to know whether the hot gases in the stove pipe were actually coming down from the stack or whether they were coming up from the ashpit. If the chimney was very tall, the draft in the chimney would overcome the suction of the steam blower as arranged in the sketch. To get positive suction from the blower, it should be set tight in the brickwork so that the en- tire suction would be inside the pipe or furnace.

JAMES E. STEELY.

Covington, Va.

Effect of Air Pressure

I was interested in reading Mr. Moore's story under the above title in the Dec. 5 issue, but on thinking it over it ap- pears that the events were not described quite as they would actually have happ- ened. Mr. Moore states that as the en- gineer opened the blowoff valve the pump "kicked." I cannot see any relation be- tween the blowoff valve and the pump that would cause it to "kick"; probably what was meant was that when the pump was relieved of the pressure which it had built up in the boiler by the opening of the blowoff, it started up. It should not have kicked on being relieved of its pressure. Then, again, he states that, as usual in this type of boiler, there were two manholes, one in each flue sheet. This is the first that I have heard that this is usual in present-day practice.

As regards our friend who got the water in the neck: If there were 172 lb. pressure on the plate, as Mr. Moore claims, it looks strange to me that it had to be rapped with a wrench to start it, as the new gasket which he had put in certainly did not stick tight enough to hold the cover plate against 172 lb. pressure when it was cold. It would ap- pear to me that with a new gasket the minute he slacked off on the nut, if there was a vacuum in the boiler, air would leak in around the gasket until the pres- sures were equalized.

It would also appear that Mr. Moore's figures on the difference in pressures on each side of the plate are not quite right as there evidently was water on the in- side of the boiler or our friend would not have got wet. The pressure due to its head would have to be taken into ac- count when figuring the pressures on the inside. Taking an area of 99 sq.in. and assuming 2 ft. of water above the man- hole would give a pressure against the vacuum inside of

$$99 \times 2 \times 0.43 = 85.14 \text{ } lb.$$

Mr. Moore also forgot to put his blow- off-pipe outlet under water as he does his barometer, for he states that they saw the water trickling out of it. If he did not, I do not see how he could get a vacuum in the boiler because the air would run up the pipe and the water would run down in gulps in much the same way as water would run out of an inverted bottle which is full.

Taking it all into consideration, it ap- pears to me that the way in which the engineer got wet was his use of enough strength to force the manhole cover in against the pressure due to the water be- hind it and his inability to get away quickly enough. Apparently the air pres- sure played no part in the matter.

O. J. RICHMOND.

Bridgeport, Conn.

On Quoting Prices

Much has been said recently about the publishing of prices, and I wish to give some of my experiences in that line.

I recently wrote to one of the ad- vertisers in POWER for a description and prices of grease cups manufactured by them. They replied, stating that they would send descriptive matter and that my inquiry was sent to their nearest branch office. The descriptive matter did not show up, but in a few days I received a letter from their branch office, stating that if I would give the size of grease cup I wanted they would be pleased to quote prices.

At another time I wrote a prominent company for a price on a hydraulic wheel press. I had their catalog and se- lected the one best suited to our needs, and sent in the description given. They replied, stating they were sending a cata- log, and, referring me to a certain page, asked me to inform them whether the press described thereon would be sat- isfactory. This press was the one on which I had asked the quotation.

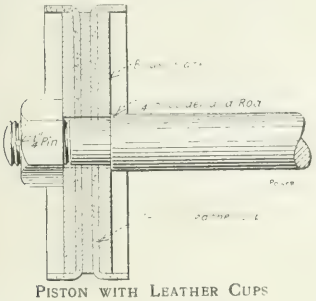
In both of these instances there was unnecessary delay and correspondence, which do not tend to promote sales.

C. E. HENRY.

Bessemer, Mich.

Leather Piston Packing

I noticed in the Nov. 28 issue the plan of packing a pump piston with leather washers, six all told, as shown in the sketch. This idea is one of the oldest known for cold water.



PISTON WITH LEATHER CUPS

The accompanying sketch shows a piston packing which will be used more in pumps if engineers will specify it for cold water.

WILLIAM NOTTBERG.

Kansas City, Mo.

The Wage Question

I have read the editorial on "The Wage Question" in the issue of Nov. 28. I believe that one of the reasons why engineers are not better paid is that, though their hourly rate is lower than in many other callings, the greater number of hours bring the pay envelope up to about what the employer thinks the engineer must have to live on. In other words, with fewer hours the engineer's rate per hour would be greater.

There are fascination and interest about an engineer's work that are absent from bricklaying or barbering, and this makes men with engineering talent prefer the work, even if the pay is not so high. It takes brains and knowledge to be an engineer, but many a man is drawing his 60c. an hour laying brick who cannot square up the lines for a pigpen or write his name. I think unionism has much to do with this and that this class of tradesmen is usually employed by contractors, who pass the cost of high wages on to the owner of the building.

Carpenters in this section get 37½c. per hour on outside work, but in mill work, where they are employed the year around, they can be hired for much less.

Engineers are not alone; the machinists, who must have knowledge and skill, usually receive not more than three-fifths as much wages as the bricklayer. The amount earned per year probably has much to do with the matter and on this point the engineer has the advantage over the building tradesman. A bricklayer friend of mine claims that very few brick masons make $600 a year.

J. O. BURCH.

Woodhaven, N. Y.

The issue of Nov. 28 contains another contribution of the above subject, which is one of which we should never lose sight.

Engineers do not lack education or wage-earning capacity nearly as much as they lack proper organization. With the existing organizations it is impossible to establish a standard wage scale because of the variation in requirements of the different plants and the too frequent willingness of some members of the same organization to "knife" each other just because the other fellow's job looks good. The ever prevailing jealousy among engineers must be got rid of and we must pull together rather than "scrap" all the time.

THOMAS M. STERLING.

Middlebranch, Ohio.

I am interested in the discussion in POWER, as to engineers' wages, and I think some good suggestions have been offered for their betterment. Some have contrasted engineering with other trades and callings, that are more successful as to wages, and hours of duty. They are so because they are better organized. Where would many of the professions be if they did not prohibit those of moderate education, influence, etc., from entering their ranks?

The engineers should unite in having laws enacted prohibiting inexperienced and incompetent persons from taking charge of power plants where lives and property are jeopardized. Then there would be more remuneration for the capable, and more incentive to forge ahead and attain some of the honors that are higher up. I read Prof. Adams' letter in the Dec. 12 number with some chagrin. He says: "When a man at home gets a 'grouch' and thinks the boss is not treating him right, just let him think of the workmen out here and forget the 'grouch.'"

I, for one, am not inclined to take his advice and I hope it will be many years before other operating engineers do. I hope the engineers will redouble their energies to improve their condition.

CHARLES MARS.

Richmond, Va.

I have been greatly interested in the numerous contributions on this topic, but I do not agree with much of what has been written so far. I have been striving to devise some remedy and I now believe I have one.

Let the young engineers who think there is more in it for them as masons, carpenters or plumbers drop their engineering work and learn one of these better-paying trades. Also, let those first-class engineers who know more about plumbing than the plumbers themselves switch right over into that trade and thereby get better wages.

This procedure will leave us who are not kicking a larger field to work in.

L. JOHNSON.

Exeter, N. H.

Engineers' Wages in China

Prof. Adams' letter in the issue of Dec. 12 gives us Americans a glimpse of oriental efficiency which is quite interesting. By way of comparison, I would like to present the wage cost per kilowatt of a New England plant with which I was associated; it was a small plant, but somewhat more difficult to handle than Mr. Adams' plant, though it was practically in the same class.

The equipment consisted of two boilers, a 125-hp. engine, supplying motive power to the shops, a 20-kw. generator and an arc-light machine. One engineer devoted his whole time to the plant, and a machinist gave about half of his time, never any more, and most of the time much less. The duties of these two men consisted of taking full care of all power-plant work, with no other assistance.

The engine and dynamo room was always in excellent order. The work included firing, cleaning and taking care of the boilers, pumps, engine, generators and motors about the plant; and care of two 50-ton electric cranes as well as the installation and care of all lighting and repairs to the steam plant. Thus, it is evident that the auxiliary work besides power generation was fully as great in this plant as in that mentioned by Prof. Adams.

The maximum pay for these men was $15 per week each, but at the time of which I write, neither was getting this pay. The power-plant cost was $22.50 per week, or $1170 per year, of 52 weeks, for the distribution of 90 kw. or $13 per kilowatt per year. Mr. Adams' wage at $43.80 per month is $525.60 per year, or $17 per kilowatt per year. In addition, he must supply means for five men to work in the way of tools, etc., and consider that the cost is raised in distributing work among five men over that necessary for such a factor between two men. Again, a certain portion of his own salary must be charged to power production, which was not the case in the plant mentioned, as the superintendent left the work entirely in the hands of the engineer.

These figures speak for themselves as to the value of intelligence. The engineer came to the shop about 5:30 a.m. and left about 6:15; on Sunday he spent an average of about five hours at the plant, while during the day on many occasions he had no actual work to do, being required simply to be in or about the engine room. The machinist worked 60 hours per week.

JAMES A. PRATT.

Williamson School, Penn.

A Pumping Problem

In regard to the centrifugal-pump problem presented by R. B. Crockett in the Dec. 19 issue, I would say that if there were no increase in friction head or eddies created in the pump, the volume pumped for the same number of revolutions would vary inversely as the square of the head; it is rather near that figure as it is.

Suppose there is an 8-ft. head and the pump is handling 10,000 gal. per minute. If the head were cut to 4 ft., the pump would handle 40,000 gal. per minute, or the equivalent of 20,000 gal. against an 8-ft. head. Hence the pump would do twice as much work as before, so if the engine is running with a fixed cutoff, is would slow down until it could do the work that the cutoff will allow.

EDWARD H. LANE.

Kansas City, Mo.

The greater the volume of water a centrifugal pump moves, the more power it takes. If the pump has to lift the water or pump it against a pressure, there is a certain amount of slippage of the impeller, and this slippage increases with the increase of the height of lift or the pressure.

A centrifugal pump requires less power to run it with the discharge pipe closed and the impeller churning the water than it does to pump through a free opening.

In Mr. Crockett's case, the rising of the river shortens the distance between the suction and the discharge, the slippage is less and the pumps move a larger volume of water and consequently require more power to run them.

L. M. JOHNSON.

Glenfield, Penn.

Many impellers, generally of old design, will overload the power end of the unit when the static head is reduced, because the capacity increases with consequent increase of velocity of water through the impeller and passages, and the friction caused by this increased velocity of water plus the increased velocity head, combined with the greater capacity, produces as great or greater a load than normal conditions of capacity with somewhat higher static head will produce. The governor being disconnected causes the engine to slow down as it is getting no more steam than before. There are also losses in the pump passages, due to high water velocity, which take power from the engine but which are not credited to the pump.

Impellers are being designed now which will not overload with a reduced static head. This condition is a necessity in the centrifugal fire pumps where a break in the pressure main might overload and seriously damage the driving motor.

W. C. DOWD.

Camden, N. J.

When the river rises, the head consequently becomes less, and more water is taken into the pump in a given time. With the lesser head, the product of the weight of water taken into the pump and the head is greater than the product of the weight of water taken into the pump and the head for the river at a medium stage. In other words, more work is done when the head is small because a greater quantity of water is handled by the pump. It is true that the water is lifted through a smaller distance, but the increase in quantity is more than enough to offset the difference in the head. As the runner of the pump is required to handle a greater volume of water, the engine driving the pump is required to do more work, and, since the governor of the engine is disconnected and the cutoff is fixed, the engine slows down under the increased load.

In order to make this clear, take the case of a centrifugal pump in which the head is so great that no water is being discharged. The runner of the pump will then merely churn the water in the pump and very little power will be required to run it. Now, suppose that the head is gradually decreased. The quantity of water discharged will be gradually increased, but the quantity of water handled by the pump will increase faster than the head will decrease, so that the work done by the pump will gradually increase. This may not be true for all speeds, as the speed of the runner to get best results should be changed to suit the head. Theoretically, the speed of the periphery of the runner should be the same as the speed attained by a body falling through a distance equal to that of the head.

T. W. HOLLOWAY.

Scranton, Penn.

When the head drops, the weight of water pumped per minute increases so that the load is increased. Thus, if the 48-in. pumps are throwing 100 cu.ft. per second at normal speed and 8½ ft. head, the engines would be delivering about 97 hp. If the head fell to 7½ ft., the pump would throw about 120 cu.ft. per second, if the pump remained at constant speed. This would require about 102 hp. With a constant cutoff, the engine will, of course, slow down until the weight of water pumped drops off so that the engine can carry the load. Further, the efficiency of the pump may be less at 7½ ft. head, and this would further increase the load on the engine.

I would hate to be around that plant if the suction or delivery pipe were to get stopped up and there were no safety cutoff on the engines. It makes me nervous to see an engine running with the governor disconnected.

GEORGE L. SULLIVAN.

Bozeman, Mont.

The reason why Mr. Crockett's pumps slow down when the river rises is because the load increases when the head decreases on a centrifugal pump. For a given speed there is a head against which a centrifugal pump will discharge no water. Thus, if a pipe is extended above this point no water will be pumped and no power will be used except that required to turn the runner in the pump.

If the discharge pipe be cut off, say, 1 ft. below the point where the pump maintains the water, considerable water will be discharged and the load will jump up in proportion to the amount pumped. If the pipe be shortened still more, the amount of water will increase rapidly and the load will get so heavy that in some cases it will stall the driving unit.

Centrifugal pumps are subject to much abuse. For a given head, there is an economical capacity, and if this be exceeded greatly, usually the efficiency falls off rapidly. It is easy to get an increase in capacity by speeding up the pump slightly, but in many cases this is a continual expense, due to decreased efficiency, which would more than buy an extra unit. Before making any changes in the speed, if it is not possible to make a test one's self, it is better to get advice from the builders as to the economy of the pump at the new speed.

JAMES E. STEELY.

Covington, Va.

[Other explanations similar to the foregoing were received from Myron D. Place, F. P. Read, Phil Lighte, A. Coffee, J. K. Blake and M. R. Frost.—EDITOR.]

What Means the Dome?

The logging engine referred to in the Dec. 26 issue interested me as I formerly was in the timber business myself, and perhaps can throw some light on the dome.

Some years ago, before sawmill men learned to do things as systematically as they do now, the men who laid the logging roads did not take the time to grade the hills, make fills and trim the track as at present. It looks to me as if the engine under discussion was designed for use in a hilly country and the dome was put on to insure steam without too much water mixed with it in going up or down hills. It was often necessary to carry the boiler full or nearly full of water to prevent the ends of the tubes and the top of the crown sheet from getting bare and burning when climbing or descending hills.

The engine may have been moved from some Northern woods to its present location after the fields for which it was built were cleaned off.

A. A. BLANCHARD.

Ocala, Fla.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Purchasing Coal on B.t.u. Basis

How is coal purchased on the B.t.u. basis, and how are the B.t.u. computed?

C. W. B.

British thermal units may be determined by using Dulong's formula, by burning coal in the presence of oxygen in a bomb calorimeter or by mixing coal with a chemical compound whose oxygen content is readily liberated and burning in a suitable receptable. In the latter two methods the B.t.u. are determined by the rise in temperature of a predetermined quantity of water surrounding the bomb or receptacle in which the coal is burned. Contracts are usually based on a specific number of B.t.u. per pound of coal. If, on analysis, the sample falls below the specified amount, the coal dealer is penalized; if above, the coal dealer receives a bonus. The percentage of moisture, ash and sulphur, in conjunction with the B.t.u., as a rule, determines the cost.

The following rule is based on the total heat of combustion of any compound of carbon, hydrogen and oxygen:

Divide the percentage of oxygen in the coal by 8 *and subtract the quotient from the percentage of hydrogen, multiply the difference by* 4.28 *and add to the product the percentage of carbon; then multiply by* 145, *and the product will be the number of B.t.u. in a pound of fuel.*

While burning a sample with oxygen under pressure in a bomb calorimeter is the standard method, a fairly accurate one is as follows:

Place 1 gram of finely powdered coal with 60 grams of litharge (lead oxide, PbO) and 10 grams of ground glass in a clay crucible; cover with a layer of salt. Next cover the crucible and heat to redness for 20 min. Then cool and break crucible and clean and weigh lead button. The number of grams of lead obtained from 1 gram of coal multiplied by 483 gives the B.t.u. in 1 lb. of coal. This is a modification of Berthier's method as described by Prof. A. H. Gill in his work on flue and gas analysis. An article on coal purchased on the B.t.u. basis will appear in an early issue.

Size of Piston Rods

What is the rule for finding the size of steam-engine piston rods?

J. L. B.

The average practice is the product of the square root of the product of diameter of the cylinder and the length of stroke in inches and 0.145 for high-speed engines or 0.11 for low-speed engines.

Assume an engine 20x48 in., substituting figures for the rule it would be expressed thus,

$$\sqrt{20 \times 48} = \sqrt{960} = 30.98$$

diameter of rod equals

$$30.98 \times 0.11 = 3.4 \text{ in.}$$

Bumped and Concave Heads

What is the rule for the pressure allowed on bumped and concave heads?

L. C.

For bumped heads multiply the thickness of the plate by ⅙ of the tensile strength and divide by 0.6 of the radius to which the head is bumped. The pressure allowed for concave heads is 0.6 the pressure allowed for convex (bumped) heads.

Load Factor and Power Factor

What is the difference between load factor and power factor?

H. A.

The load factor of an electric plant is the ratio of the average to the maximum output. The ratio of the real watts to the apparent watts is the power factor. The power factor is that quantity by which the apparent watts expended in the system must be multiplied in order to give the true watts; it is numerically equal to the cosine of the angle the amperes lag behind the voltage.

Suppose it is desired to transmit 100 kw. over a line, and the current lags behind the voltage by an angle of 25 deg. The cosine is then equal to 0.90, and the power factor will be 0.90. The true watts will equal the apparent watts × 0.90 or volts × amperes × 0.90. If the voltage used in transmission is 1000, 100,000 ÷ 1000 × 0.90 = 111.1 amperes. If the power factor had been unity, only 100 amperes would have been required.

Power for Chain Block

If a chain block is operated by a motor having a speed of 2500 r.p.m., what power would be required to lift 1000 lb? If it took 1 hp. to raise this weight 30 ft. and the weight was suddenly released, what power would it develop in descending?

J. F. M. I.

To lift 1000 lb. at the rate of 30 ft. a minute would take

$$30 \times 1000 = 30{,}000 \text{ ft.-lb. per min.}$$

A horsepower is 33,000 ft.-lb. per min.; therefore it would take

$$\frac{33{,}000}{30{,}000} = \frac{10}{11} \text{ hp.}$$

applied to the weight. The power applied to the shaft of a hoist would depend upon the efficiency of that mechanism. If the efficiency, for instance, were 80 per cent., the power required would be

$$\frac{\frac{10}{11}}{0.80} = 1.136 \text{ hp.}$$

The weight in descending would develop

$$30 \times 1000 = 30{,}000 \text{ ft.-lb.}$$

of energy. The amount of power developed would depend upon the velocity of its descent. If it took it a minute to fall, the average horsepower developed by the weight would be

$$\frac{30{,}000}{33{,}000} = \frac{10}{11} \text{ hp.}$$

If in a second,

$$\frac{30{,}000}{550} = 54.5 \text{ hp.}$$

The time required by a body to fall freely through a given height is, square root of the height ÷ 4.01. The square root of 30 = 5.48, and 5.48 ÷ 4.01 = 1.37 sec. The average power developed upon itself in falling freely will be

$$\frac{30{,}000}{1.37 \times 550} = 39.8 \text{ hp.}$$

This increase of horsepower does not represent a gain; it is simply a more rapid use of the available 30,000 ft.-lb. of energy, which cannot be increased by any mechanical device, nor in any other way than by the conversion of other energy.

Galvanized Iron Ammonia Pipes

What is the objection to using galvanized pipes in double-pipe ammonia condensers?

W. J. C.

The only objection is that the ammonia is disintegrated by the material used in galvanizing the pipe and some scale and noncondensible gases are formed. For this reason galvanized pipe is used only when the condensing water is so bad that there is a distinct advantage in its use. The inner pipes of double-pipe condensers are for this reason quite frequently galvanized.

Equitable Life's Fire

Severe criticism has been directed against Arthur C. Davis, chief engineer of the Equitable Life Assurance Society's home-office building at 120 Broadway, New York City, for having attempted, with his men and apparatus, to quench the fire which later destroyed that building on the morning of Jan. 8, instead of sending in an alarm when the fire was first discovered.

Mr. Davis declared the next day that he did not know who turned in the alarm; that his first thought was for the seven 125-hp. boilers in the basement carrying a pressure of 85 lb., and that if the fires were not drawn there would be an explosion which would cause great loss of life.

He also explained that he worked "from 5:30 a.m. until noon drawing the fires from the seven boilers," and "then only escaped by prying open a frozen door with a crowbar." How the chief engineer of a big plant like the Equitable, the successor of James Wilson, happened to be in the building at that early hour unless he had an intimation of trouble is yet to be explained.

Much credit is given by the daily press to the engineers of the adjacent office buildings for their valuable assistance to the fire department. It was necessary, owing to the lack of pressure and the sixty-mile gale that scattered the streams of water, to couple 15 or 20 lines of hose to the standpipes of these buildings, and even to utilize the standpipes on the fifth and sixth floors.

Several of the office-plant engineers remained on watch over 28 hours for the purpose of keeping the fire pumps running. Chief Engineer Trolsen, of the Hanover Bank Building, was on duty throughout the fire directing his force and the working of the pumps pressed into service by the fire department.

The accompanying illustration is typical of the appearance of the fire engines and the conditions under which the fire department's engineers had to labor. It is hard to believe that this ice-encased engine is pumping its quota of water while ice-locked to a street which is ordinarily one of the busiest and most crowded thoroughfares in the world.

PUMPING WATER UNDER DIFFICULTIES

This conflagration illustrates the general neglect on the part of employees to promptly obey the injunction of every fire department: "Send in an alarm first!" If this had been done, this fire might have ended in a petty blaze instead of becoming a conflagration which caused a shocking loss of life and property.

The lesson is plain that wherever oil and waste, exposed heaps of rubbish or other combustible material are allowed to collect, the fire hazard is enormously increased. And cleanliness and care are as necessary to safeguarding life and property in a power plant as elsewhere.

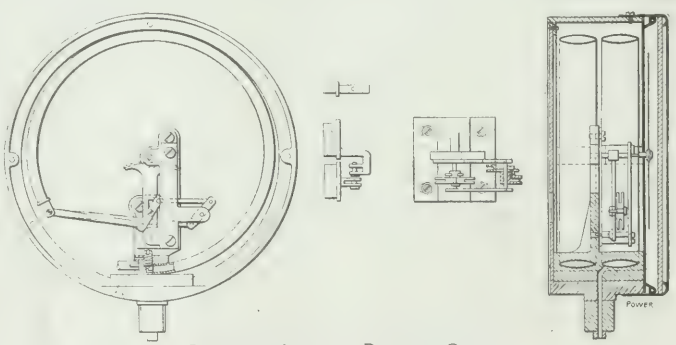
Absolute Pressure Gage

In large plants where the units are operated condensing, it is of great importance to be able to ascertain with accuracy the absolute pressure in the condenser, as with a big unit even a fraction of an inch of mercury difference in the vacuum means a large gain or loss in the steam required to develop a given output.

The ordinary vacuum gage is influenced by the changes in atmospheric pressure as well as the changes in vacuum in the condenser. In other words, it is merely a differential gage, showing the difference in pressure that exists between the inside and the outside of the condenser.

The gage herewith illustrated indicates the absolute pressure that exists within the condenser irrespective of the atmospheric pressure without. It is described in the London *Engineer* as follows:

The gage consists essentially of two Bourdon tubes coupled in such a manner as to oppose each other in their action. The inside of one tube communicates with the inside of the condenser while the outside is open to the atmosphere. This tube therefore is actuated by the difference between the atmospheric pressure and the absolute pressure in the condenser. The other tube is evacuated and sealed and therefore is actuated only by the changes of atmospheric pressure.



DESIGN OF ABSOLUTE PRESSURE GAGE

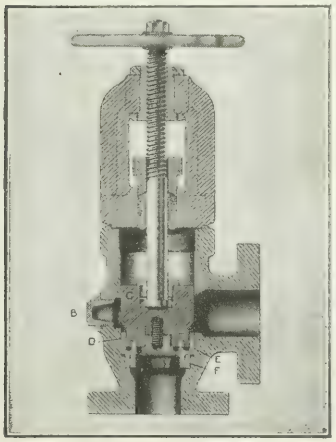
Thus, if the absolute pressure in the condenser increases from, say, 2 to 4 in. while the atmospheric pressure remains the same, the finger of the dial will be advanced accordingly and 4 in. absolute pressure will be indicated. If, on the other hand, the absolute pressure in the condenser increases from, say, 2 to 4 in. while the atmospheric pressure falls 1 in., the increase of pressure inside the tube would be 2 in. and the pressure outside the tube would decrease 1 in., and the resultant motion imparted to the pointer of the ordinary gage would indicate a change of 3 in.

In the absolute pressure gage, here described, the atmospheric pressure acts also on the outside of the evacuated tube and the fall in pressure will permit this tube to expand and thus oppose the action of the other tube to the extent of 1 in., the resultant motion transmitted to the pointer will be equal to 2 in. and an indication of 4 in. absolute pressure will be indicated by the pointer.

In the accompanying figure it will be seen that the two tubes are not coupled direct to the quadrant; their motion is transmitted by a compensating link motion which removes the difficulty of the operating tube having to overcome the effect of the elasticity of the other tube and avoids at the same time the friction which would be produced by the two tubes acting on one pinion in opposite directions.

An Improved Blowoff Valve

A great fault with some types of blowoff valve is that the seat is so located



THE "DURO" BLOWOFF VALVE

that as the disk approaches it the conditions are favorable for the accumulation of scale and sediment. Often the effect of such accumulation is to cut the bearing surfaces to such an extent as to cause the valve to leak. The valve herewith illustrated is the "Duro" blowoff valve, manufactured by the Lunkenheimer Co., of Cincinnati, Ohio; it is designed to overcome the difficulty just specified.

The plug *C* carries the reversible double-faced disk *D*. The bronze seat ring *E* is screwed into a second ring *F*, which is of brass. The object of this is to make the renewal of ring *E* easy in case it becomes worn. There is a plug *B*, at the back, which may be taken out whenever it is desired to clean the valve.

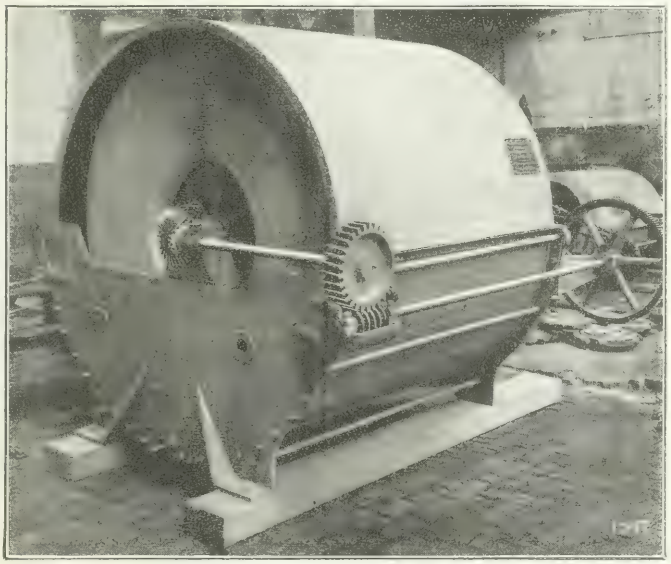


FIG. 1. ROTOR END OF THE WATER COOLER

Power Water Cooler

This machine has been designed for the purpose of cooling the circulating water for internal-combustion engines, air compressors, ammonia condensers, etc. The machine consists of a horizontal

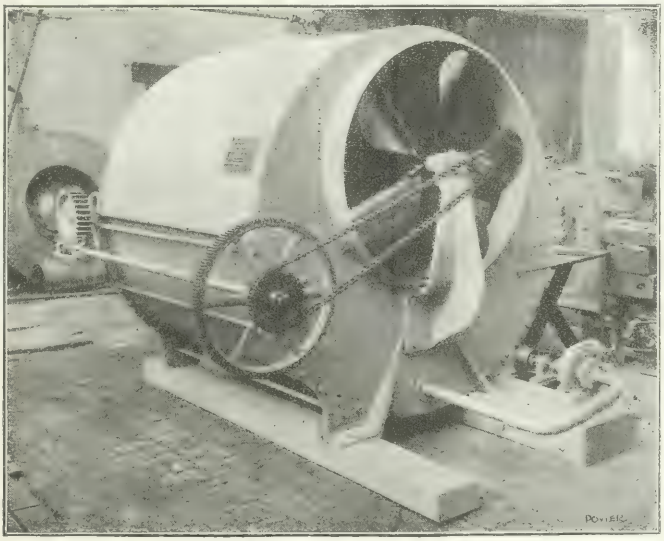


FIG. 2. FAN END OF THE WATER COOLER

casing, through which air is passed, a rotor within the chamber which forms a revolving cooling surface, a fan for circulating the air and a pump for circulating the water to be cooled.

The casing is made of sheet iron, cast iron or concrete, according to size, the lower part of the casing forming a trough in which the water circulates. The rotor fills the casing and is made up of thin annular plates which are supported from a central shaft, as shown in Fig. 1. The fan is mounted at the end of the casing and blows air between the plates.

Air and water are passed through the machine in opposite directions, thus forming countercurrents. As the plates of the rotor slowly revolve they pass through the water in the trough and through the air in the upper portion of the chamber.

This brings the wet surface of the rotor into contact with the current of air at each revolution. The thin film of water on their surfaces is partially evaporated by the air which causes the heat given off by the water to be rendered latent; heat is also extracted from the water by a conductor.

The cooler operates noiselessly and, being compact, occupies but little space. It can be set on the floor or placed on brackets on the wall, as shown in Fig. 3.

This machine is manufactured by the Power Specialty Company, 111 Broadway, New York City.

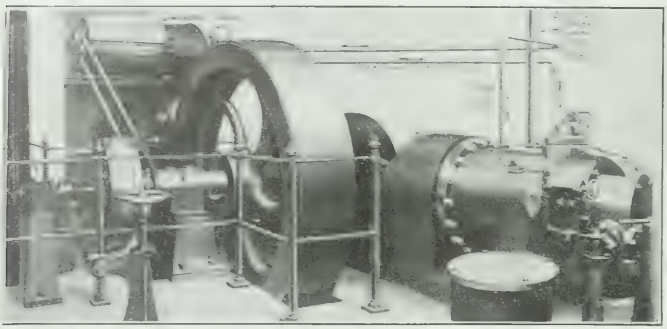
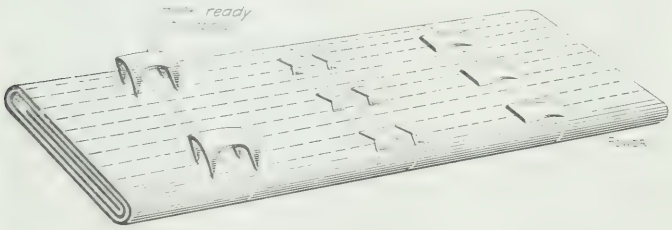


FIG. 3. WATER COOLER AND PIPE CONNECTION TO A GAS ENGINE

"Climax" Belt Hook

One would scarcely suspect that the design of such an apparently simple thing as a belt fastener or hook would be the subject of any very great study. But that such is actually the case is indicated by the number and variety of these devices on the market. One of the newest is the "Climax" belt hook, illustrated herewith.

The "Climax" hook is so made that it enters the belt parallel to the warp, or longitudinal strands, and hence does not cut any of them. An advantage of this form of hook is that while the grip of the hook is in no way impaired, practically the full strength of the fabric of the belt itself is retained. With the "Climax" hook either side of the belt may be run to the pulley with satisfaction. Thus the use of idlers is permitted with belts that are joined with these hooks.



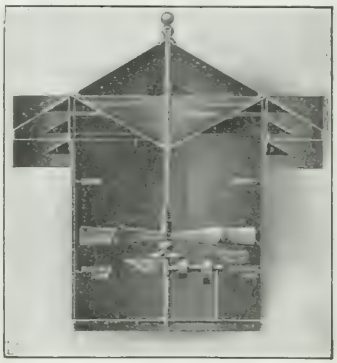
"CLIMAX" BELT HOOKS

The "Climax" belt hooks are manufactured by the Hudson Belt Fastener Company, 136 Liberty street, New York City.

Induced Draft Ventilator

For all ordinary ventilating purposes, the standard natural-draft type of ventilator is entirely sufficient; for some special purposes it is not, as, for instance, that of ventilating a blacksmith shop, a laundry or any other structure in which excessive gases, vapors, fumes, etc., are liberated.

The Burt Manufacturing Company, 232 Main street, Cleveland, Ohio, has just devised and put on the market an addition to its already large family of ventilators in the form of an induced-draft ventilator which is designed for such special purposes as those just mentioned. This new type of ventilator is made in two sizes, 36-inch and 48-inch. The fan, which makes from 250 to 300 revolutions per minute, may be driven by a belt or a direct-connected motor; the power required for each size is about ¼ horsepower. If desired, the fan may be reversed so as to force fresh air into the building instead of drawing off the foul air from within.



THE BURT FAN INDICATOR

The chains by means of which the damper in the top of the ventilator is adjusted have fusible links which will melt out in case of fire and allow the damper to close of its own weight and automatically cut off the draft.

It is said that this type of ventilator will remove about ten times more air within a given length of time than the ordinary stationary type.

New Vulcan Corliss Valve Gear

When the Vulcan Iron Works began the manufacture of mine-hoisting apparatus in 1849, a small steam engine was sufficient to provide all of the power that was necessary to operate the works. Later, as the business increased and various kinds of colliery apparatus was manufactured, a larger power plant was installed which included two 14x18-in. side-crank automatic engines, both of which ran at a speed of 200 r.p.m. and were each belt connected to an Edison bipolar, 220-volt, direct-current generator.

The latest additions to the power plant is shown in Fig. 1. These are two 200-kw. engines, each direct coupled to a Westinghouse 250-volt, direct-current generator and run at a speed of 120 revolutions per minute.

The engines are installed in a brick addition to the old power plant. The engine room is exceedingly light, owing to the large windows on three sides of the building. The floor is of hard-wood

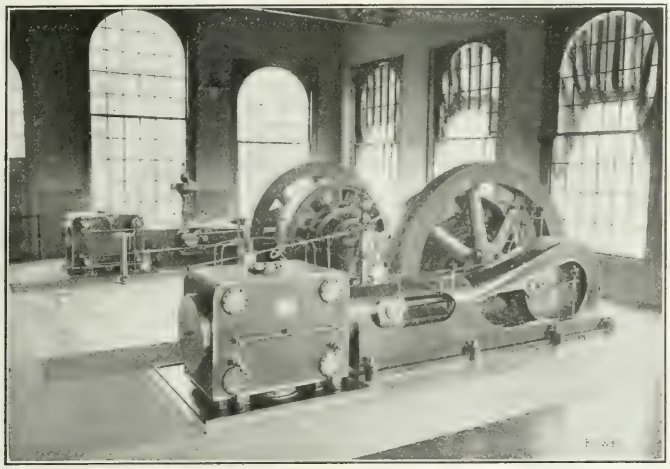


FIG. 1. NEW ENGINE ROOM OF THE VULCAN IRON WORKS, WILKES BARRE, PENN.

finish, with rubber floor matting around each engine.

The most interesting feature about these engines is the new valve-gear with which the right-hand engine, shown in Fig. 1, is equipped. This valve-gear is built by the Vulcan Iron Works, as are both of the engines.

The main object in designing this valve-gear was to reduce the parts to a minimum, to obtain noiseless operation, to bring the pull on the valve stem as close to the engine cylinder as is practicable, and to obtain a valve-gear suitable for high-speed Corliss engines. The valve stem is fitted with an arm which supports a steel latchplate. The dashpot rod is connected to the latchplate arm and the valve is closed as soon as the latch blocks are released.

On the knock-off collar there is mounted a safety cam. There is no knock-off cam as the knock-off collar is made with a suitable knock-off projection, which has easy lines and is so arranged that the cutoff occurs the same as if a knock-off cam were employed.

The other member of the gear swings on the valve-stem bonnet and is actuated by a carrier arm, which connects with a rocker-arm that is operated by the steam eccentric. A stud is fitted in at the bottom of the actuating arm and supports a Y-member, to which is secured a steel catch-block. A thumb-screw passes through the straight arm of the Y-member and screws into a stud that is fitted into the actuating arm. The amount of tension on the knock-off arm against the knock-off collar is regulated by a spring, as shown in Fig. 2.

The Y-member, at the "pick-up" position, tends to fall by gravity into engagement, this tendency being assisted by centrifugal force. The spring is used to overcome the inertia of the latch and cushion its return at disengagement.

The Y-member is fitted with a strip of leather which bears on the knock-off collar. This feature, together with the slight spring tension, renders the valve-gear practically noiseless, and its design makes it capable of running at speeds up to 300 revolutions per minute.

In Fig. 3 is shown the valve-gear hooked in ready to open the valve; Fig. 4 shows the valve unhooked and the reach rod about to travel toward the left.

The design of the gear is such that the force exerted in opening the valve is practically in a straight line with the reach rod. The valve is pushed open by the reach rod moving the Y-member toward the center of the cylinder, and as soon as it is disengaged the valve is closed by the dashpot.

This power plant is in charge of Chief Engineer Edward D. Whitebread, who takes much pride in his work, and the condition of the plant shows that he is fully capable of filling the position he holds.

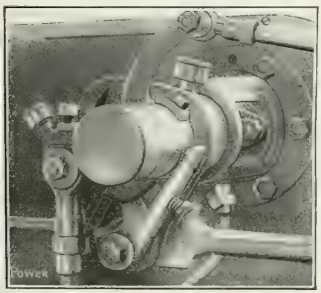


FIG. 2. SHOWING KNOCKOFF COLLAR AND CAM

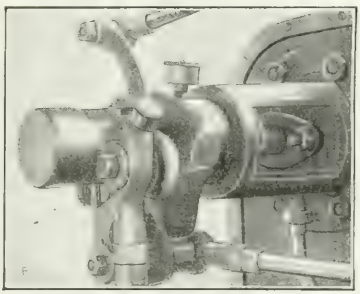


FIG. 3. VALVE GEAR ENGAGED READY TO OPEN VALVE

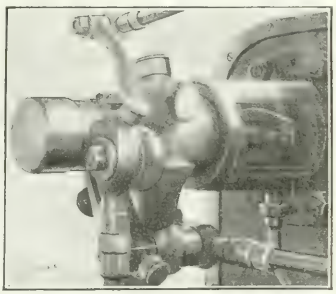


FIG. 4. VALVE GEAR DISENGAGED AND VALVE CLOSED

Bureau of Mines' New Publications

The Bureau of Mines has copies of the following publications for free distribution, one copy to each person.

Bulletin 6, "Coals Available for the Manufacture of Illuminating Gas," by A. H. White and Perry Barker. No. 16, "The Uses of Peat for Fuel and Other Purposes," by Charles A. Davis. No. 19, "Physical and Chemical Properties of the Petroleums of the San Joaquin Valley, Calif.," by I. C. Allen and W. A. Jacobs; with a chapter on analyses of natural gas from the southern California oil fields, by G. A. Burrell.

Reprints—Bulletin 21, "The Significance of Drafts in Steam-boiler Practice," by W. T. Ray and Henry Kreisinger. Reprint of Bulletin 367. No. 26, "Notes on Explosive Mine Gases and Dusts," by R. T. Chamberlin. Reprint of Bulletin 383. No. 29, "The Effect of Oxygen in Coal," by David White. Reprint of Bulletin 382. No. 30, "Briquetting Tests at the Fuel-testing Plant, Norfolk, Va., 1907-8," by C. L. Wright.

Locomotive Explosion at Los Angeles

A locomotive-boiler explosion in the roundhouse of the Southern Pacific R.R. on Lamar St., Los Angeles, Calif., on the night of Jan. 5, caused the death of two men and the injury of three others.

The engine had been employed in local freight service and at the time of the explosion was occupying the first stall at the extreme end of the 48-stall roundhouse. The explosion was caused by low water, followed by the collapse of the crown sheet to such an extent, it is stated, that it dropped into the firebox. The report of the local fire department that the boiler was being filled with cold water at the time of the disaster is denied.

The boiler disengaged itself from the locomotive proper, leaving the engine trucks, wheels and tender standing demolished over the repair pit of the roundhouse. The boiler was blown through the roof of the building and landed at a point in the shop yards about 100 ft. distant. Another engine in the roundhouse was partially damaged through the force of the explosion, and burning timbers from the roundhouse roof caused a slight fire in an adjoining shop building.

The board of inquiry appointed to investigate the cause of the accident has reported as follows: "We are of the unanimous opinion that the cause of the explosion was due to lack of sufficient water on the crown sheet, and that the lack of water on the crown sheet was entirely in the hands of Engine Watchman W. A. Weaver, who was solely responsible and lost his life in the explosion."

Boiler Explosion at Colliery

A boiler explosion on Jan. 13, at Pittston, Penn., in the Clarence colliery of the Hillside Coal & Iron Co. is reported in the daily press. It appears that the wrecked boiler was one of a battery of five and, although there was considerable property damage, the explosion did not result in loss of life or even injury to the employees.

Westinghouse Company Elects Chairman

Guy E. Tripp, of Boston, formerly chairman of the reorganization committee of the Metropolitan St. Ry. Co., was elected chairman of the Westinghouse Electric & Manufacturing Co. on Jan. 10. The office has been vacant since the death of Robert Mather, and the directors considered a large list of men of experience in electrical and railway matters before coming to a decision.

Mr. Tripp, in order to conduct the operations of the Westinghouse company, with its numerous branches in England, France, Germany, Canada and Russia, withdrew recently from the firm of Stone & Webster. He has been connected with local traction matters for a number of years.

Power Merger

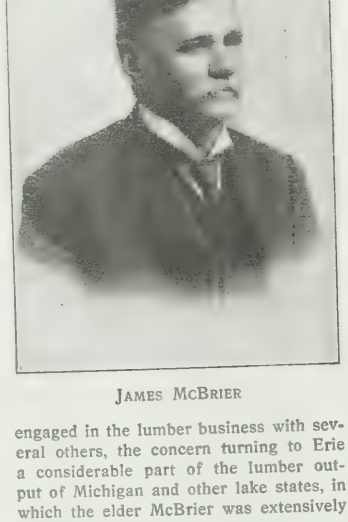
There was formally presented to the Public Service Commission, Second District, on Jan. 10, a plan to reorganize the various power companies along the upper Hudson River into a new corporation, to be known as the Adirondack Electric Power Corporation.

The properties proposed to be consolidated are the Hudson River Water Power Co., the Hudson River Electric Co., the Hudson River Electric Power Co., the Hudson River Power Transmission Co., the Saratoga Gas, Electric Light & Power Co., the Ballston. Spa Light & Power Co., the Madison County Gas & Electric Co. and the Empire State Power Co.

OBITUARY

James McBrier, president of the Ball Engine Co., a brief notice of whose death was published in the issue of Jan. 16, was born in Allegheny, Penn., in 1835, the son of William and Mary (McMasters) McBrier.

Mr. McBrier came to Erie in 1872 and



JAMES McBRIER

engaged in the lumber business with several others, the concern turning to Erie a considerable part of the lumber output of Michigan and other lake states, in which the elder McBrier was extensively interested.

In 1887, he located permanently in Erie, and in that year he became interested in the Ball Engine Co., which was then a newly formed corporation. His business acumen, judicious management and progressive methods as president of the company quickly paved the way for the success which it has since enjoyed.

Mr. McBrier's business interests also included the lake carrying trade, and he was a most important factor in obtaining some of the national appropriations which deepened channels, enlarged locks and improved the lake waterways, which have made possible the safe navigation of the 12,000-ton carriers of today. He had held the office of vice-president of the Lake Carriers' Association and was interested in the Erie Steamship Co.

His unaffected and strong personality gained for him the greatest respect, and his active interest in municipal affairs soon identified him with many of the foremost financial and industrial interests of Pennsylvania.

Mr. McBrier was married in 1855 to Mary E. White, who survives him. Their children are David N., vice-president of the Ball Engine Co.; Frederick, secretary; Harvey L., Mary L. McBrier, and Mrs. Alexander Jarecki.

Franklin Farrel, president of the Farrel Foundry & Machine Co. since 1857, died at his home in Ansonia, Conn., on Jan. 10. Mr. Farrel's capacity for hard work often led him to toil for hours in the foundry, begrimed as were his hundreds of employees. His son, Franklin Farrel, Jr., after his graduation from Yale nine years ago, entered his father's foundry and is today one of the heads of the concern. Mr. Farrel's wealth is estimated to be between $10,000,000 and $15,000,000.

PERSONAL

F. L. Morse, treasurer and manager of the Morse Chain Co., Ithaca, N. Y., is now convalescing from a successful operation for appendicitis.

H. M. Glazier, instructor in architectural engineering, Pennsylvania State College, has resigned to accept an offer in the architectural field with a large company in Cleveland, Ohio.

John K. Bulger has been appointed supervising inspector of the United States steamboat inspection service of the first district, Pacific Coast, at San Francisco, Calif. The position carries a salary of $3000 per annum, and includes jurisdiction over both boilers and hulls. Mr. Bulger was formerly chief assistant, as inspector of boilers, to the late Capt. John Bermingham.

Joseph P. Dolan, assistant inspector of boilers at San Francisco for the service during the past 10 years, has been appointed inspector of boilers, filling the vacancy caused by the promotion of Mr. Bulger. The position pays $2250 per annum. Mr. Dolan will collaborate with O. F. Bolles, inspector of hulls, in the examination of applicants for mariners licenses, in the investigations of accidents and violations of the boiler and navigation laws.

POWER

Vol. 35 NEW YORK, JANUARY 30, 1912 No. 5

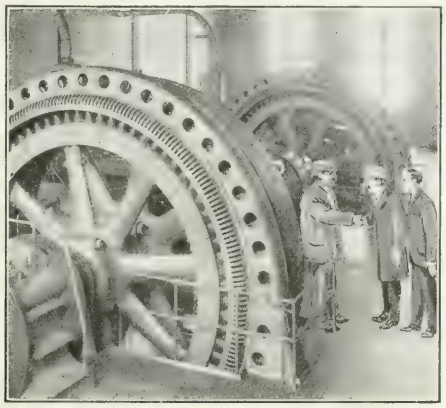
THIS is not a fairy tale. It is a truthful picture of what took place a few days ago and the conditions mentioned herein actually obtained.

The writer visited a modern power plant which was a work of engineering art. Many dollars had been spent in devices which improved the appearance of the plant and were for the accommodation of the employees rather than for safety and economy.

The engine and boiler rooms were large and light and the machinery was arranged with an eye to symmetry. There was a washroom equipped with a shower bath; also a tub and hot and cold water for the engineers and firemen.

There is some difference between this and the old way of washing up in a pail of hot water out in the boiler room, where the soap was full of cinders and the towel often trailed in the dirt while hanging from a hip pocket.

The owners of this power plant were proud of their installation, and justly so. Of course, it was expected that the chief engineer would be in keeping with his surroundings, but when the introduction came it was noticed that his hands were dirty; his vest showed signs of soup droppings and the lapel and collar of his coat were greasy —in short, he was sloppy.



But how differently appeared his subordinates!

Out in the boiler room the firemen were found to be a clean-looking set of men, and the chief engineer's appearance was not improved by the comparison.

When we were alone the owner apologized for his engineer's appearance. He could not understand why so skilled a mechanic could be content to remain so unkempt. He expressed the hope that some time his engineer would clean up and put himself in keeping with the rest of the plant.

Think of it, the owner making apologies for the dirty appearance of his engineer!

Getting down to rock bottom, what does the owner of your plant think of you? Is he obliged to make apologies for your appearance? Is he ashamed of your looks when visitors are about?

Are the firemen and oilers neater than their chief?

Small boys and dogs are usually dirty. It is expected of them; the boy is so busy playing that he has no time for soap and water. The dog doesn't know any better. But men having a bathtub and hot and cold water at their disposal—conveniences which our grandfathers never heard of—have no excuse for being unclean and slovenly.

Line up with your plant and then there will be no need of apologies by the plant owner.

British Practice in Superheating

By Victor White

The advantages of using a moderate degree of superheat are discussed and a number of types of superheaters used extensively in England, are described.

The addition of a moderate amount of superheat effects a saving of steam even in well arranged modern power plants, and where the engines are separated from the boilers by long lengths of steam piping, the advantages of superheating are marked. In a reciprocating engine the benefit is evidenced in the raising of the expansion curve of the indicator diagram, and the effect of reëvaporation toward the end of the stroke is not so marked. Apart from the losses in the steam piping, with the necessity for an elaborate and wasteful system of traps, and the lost work due to initial condensation in the cylinder, saturated steam escapes more freely past the pistons and valves.

In Fig. 1 are shown the results of tests with superheated steam carried out by Belliss & Morcom, Ltd., of Birmingham, on one of their high-speed triple-expansion engines, which is self-explanatory. It

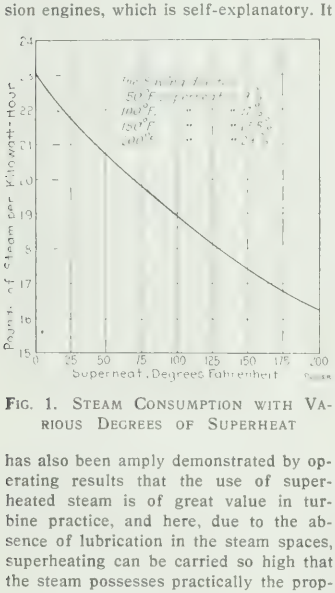


FIG. 1. STEAM CONSUMPTION WITH VARIOUS DEGREES OF SUPERHEAT

has also been amply demonstrated by operating results that the use of superheated steam is of great value in turbine practice, and here, due to the absence of lubrication in the steam spaces, superheating can be carried so high that the steam possesses practically the properties of a perfect gas.

Having regard to these points, it is therefore interesting to note some of the latest designs which now find a place in British superheater practice. Given a proper heat-transmission efficiency from the gases to the steam to be superheated, the determining factors as to the excellence of design are mechanical strength, accessibility and reliability of operation. Controllability is also very important, particularly in independently fired superheaters, where the steam demands vary, for if a very small quantity of steam passes through the superheater while a full blast of heat is upon the tubes, the degree of superheat would be much greater than when a heavy load and a scanty heat supply were prevalent. A superheater must always be designed to give full (or even a small excess) superheat under the worst conditions of load; therefore it should have means for controlling during light loads. Moreover, if there were no such control the probability is that under the first of these conditions the tubes would become overheated and would be liable to burn.

Where several large boilers are used, it has often been found less expensive and better in operation to have one large independently fired superheater serving the whole range of boilers instead of including a small superheater in each steam unit.

WATKINSON SUPERHEATER

A type of superheater, designed by Professor Watkinson, of the Liverpool University, and made by Mechan & Sons, Ltd., of Glasgow, is shown in Fig. 2. As applied to a Lancashire boiler, the superheater is placed in a separate compartment behind the rear chamber of the boiler, being separated therefrom by a perforated firebrick wall, underneath which a damper is placed. When the damper is in the vertical position the products of combustion do not flow over the superheater tubes, but pass direct to the bottom flue of the boiler. When the damper is in the horizontal position, all the gases flow over the superheater tubes and, by varying the position of the damper between these limits, the degree to which the steam is superheated may be regulated. This control gear is operated from the front of the boiler, as shown, and the hot gases can be shut off from the superheater during the time steam is being raised or when the engine is not running. In some types the tubes become red hot whenever the engine is stopped, and provision has to be made for "flooding" the superheater; that is, filling it with water so that the apparatus may not be damaged. This is often considered objectionable as it may cause rapid deterioration of the tubes and lead to dangerous water-hammer. The damper, being protected from the high-temperature gases, does not suffer undue deterioration, and the firebrick wall between the boiler and the superheater acts as a heat reservoir, maintaining the temperature of the gases when the furnace doors are open. The brickwork also absorbs heat during periods of most rapid combustion, and thus acts as a regulator of the temperature of the gases supplied to the superheater. With the Watkinson superheater, the heat utilized per pound of coal burned, when the rate of evaporation remains the same, is increased by about 5 per cent., owing to the additional heat-absorbing surface of the superheater. The amount of heat required to superheat the steam 150 degrees Fahrenheit is about 7 per cent. of that required to generate the steam; therefore, the additional coal required to superheat the steam is only 2 per cent. The superheater is constructed entirely

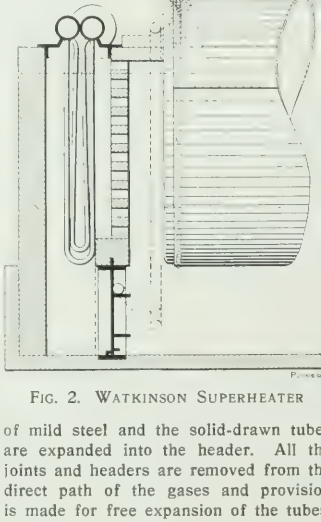


FIG. 2. WATKINSON SUPERHEATER

of mild steel and the solid-drawn tubes are expanded into the header. All the joints and headers are removed from the direct path of the gases and provision is made for free expansion of the tubes.

MCPHAIL & SIMPSON SUPERHEATER

A McPhail & Simpson superheater placed in the downtake of a boiler is shown in Fig. 3. Tubes can be removed if necessary from the boiler top without disturbing the working of the steam plant, by a slight modification of the headers. No damper is employed and the superheater, which is constructed entirely of solid-drawn wrought steel does not interfere with the accessibility of the boiler itself. The headers are strongly supported on the boiler setting and a safety valve and thermometer pockets are provided.

Another type of superheater used extensively in England is the Foster. This is so well known in America, however, that a description would be unnecessary for the readers of POWER.

GORDON SUPERHEATER

A superheater of distinctive design which has been used extensively in England, is the sectional superheater made by James Gordon & Co., of London. The construction will be understood by reference to Fig. 4, which represents a collection of the component parts of the superheater. All the parts are of wrought steel and the sectional design is to prevent that more or less lengthy stoppage which is necessary in some superheaters when a tube has to be removed or reëxpanded. If a tube requires attention or a joint remaking, it is necessary only to remove that section of tubes, replace it with a spare section, drop in fresh joint rings or put on blank flanges, which are provided for the purpose; all this can be done with the boiler under steam. There is no large joint to break and remake, involving the removal of a large number of bolts, disturbing pipe joints and finishing with the troublesome task of remaking the joint again, and there is no wasting of heating surface by the "stoppering" of defective tubes. All the joints are so situated as to be out of the path of the flue gases, and can be examined while the plant is working. Owing to the sectional design, no lifting tackle is required for erection, the headers being first placed in position and then the tubes put in and assembled section by section.

It is sometimes an advantage to combine with the superheater a damper arrangement to partially or entirely bypass the flue gas during periods of inspection or when raising steam, or if required for reducing the amount of superheat. The type of damper used by James Gordon & Co. is in the nature of a horizontal baffle capable of being moved vertically and suspended on rods which are raised or lowered from the front of the boiler. In its lower position the furnace gases are projected past the superheater tubes, and when it is raised they choose a shorter path in the downtake, missing the tubes. This type of damper has been adopted with a view to overcoming some of the difficulties which are met with in ordinary swivel dampers, such as the damper spindles warping and jamming, or distortion of the swivel damper itself, owing to the high temperatures.

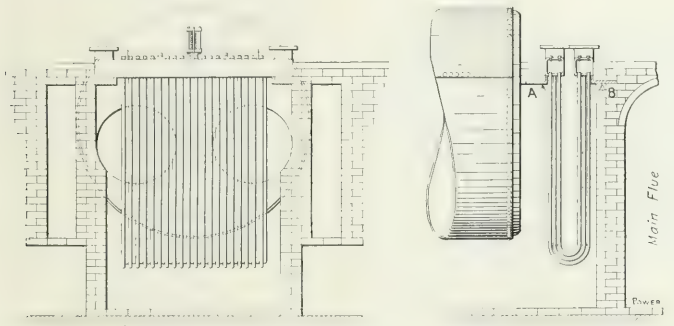


FIG. 3. MCPHAIL & SIMPSON SUPERHEATER

GALLOWAY'S SUPERHEATER

It would be difficult to present within reasonable compass a description of all the types of superheaters of modern construction which have been adopted in the power plants of Great Britain, inasmuch as developments in design are constantly proceeding in order to meet the requirements outlined in the opening paragraphs and also special difficulties as they arise. This portion of the subject must therefore be concluded by reference to three of the latest developments in design which each has as noteworthy features. The first is the new type of superheater which has been introduced by Galloways, Ltd., of Manchester.

The new type of superheater introduced last year by this firm is a distinct improvement upon the older type, and is shown in Fig. 5. It consists of two separate wrought-steel headers of circular form, flanged at one end and closed at the other. Each is bored for the tubes, and is further provided with a special opening opposite each nest of five tubes, these openings being fitted with special internal and external caps so arranged that each internal cap can be inserted into or removed from the superheater through its own or any other of the handhole openings. The tubes are U-shaped, 1½ inches bore, 1⅝ inches outside diameter, are of solid-drawn steel, and are expanded into the headers. The flanges are suitable for the attachment of 7-inch inlet and outlet pipes. The headers are rigidly stayed to each other by strong clips, and the superheater rests in a cast-iron tray or box of special section, suitably arranged for lining with insulated material, this tray being provided with a loose lid or hood, not shown, thus entirely inclosing the superheater. A 1½-inch open-type spring safety valve with easing gear is fitted in a suitable position, and a cast-iron plate is provided to carry the brickwork for the downtake, these plates being of tee section. The header boxes are well away from the direct path of the gases, and are raised above the brickwork with the special object of obtaining complete accessibility and good drainage.

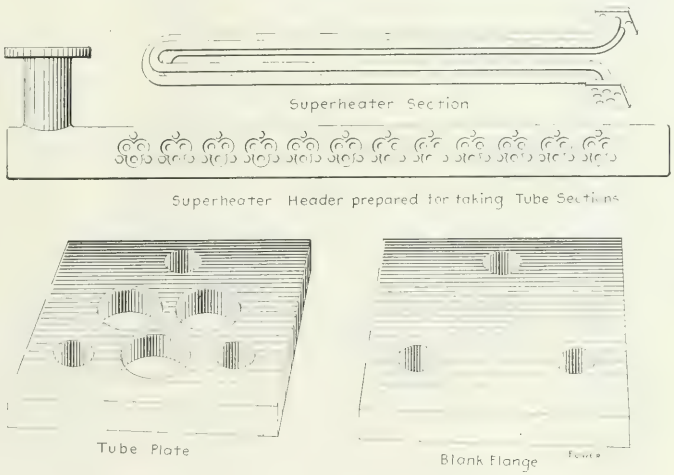


FIG. 4. PARTS OF GORDON SUPERHEATER

HERBERT SUPERHEATER

The second type which may be mentioned in this connection is that de-

signed by Charles Herbert and made by Tinker, Shenton & Co., Ltd., of Manchester. The distinguishing feature of this superheater, which is shown in elevation in Fig. 6, is accessibility. The circular form of the headers is the best form for withstanding steam pressure; also, the tubes, being expanded radially

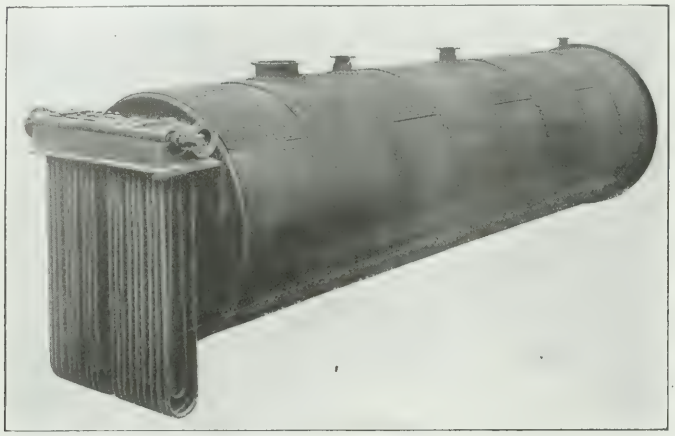


FIG. 5. GALLOWAY SUPERHEATER

to the headers, provide the desired facility of access to each individual tube for cleaning, inspection or replacement. The steam entering the internal header passes down the inner tubes and returns up the tubes with closed ends to the annular space contained in the outer header, and thus to the outlet branch. As there is

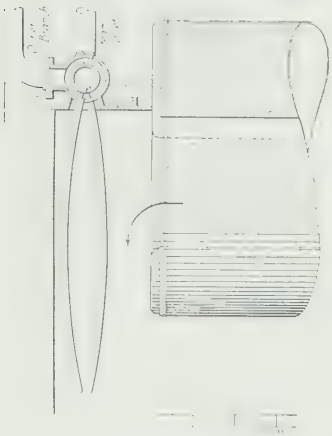


FIG. 6. HERBERT SUPERHEATER

much greater sectional area through the superheating tubes than through the main steam pipe, the steam passes slowly through the tubes and a uniform degree of superheat is obtained. The heating surface is proportioned to raise the temperature of the steam about 150 degrees Fahrenheit, a moderate degree of superheat which has now become the common practice, for large steam plants throughout Great Britain. The great advantages of the pendent form of tubes are: First, they are free to expand or contract with the varying temperatures, being held at one end only; second, the steam is split up into a thin film between the inner and the outer tubes and so passes the heating surfaces in the form most easily heated.

SIMPLEX SUPERHEATER

The remaining type of superheater differs essentially from those previously described in that the steam is dried by means of channels formed of steel boiler plating instead of tubes. This superheater, shown in Fig. 7, is made by the Simplex Superheater Co., Ltd., of London, and consists of a box-like receiver in which there are a number of diaphragm plates dividing the superheater into a series of compartments, spaces being left alternately at the top and the bottom of the diaphragms so that the steam shall take a zig-zag course and be well mixed during its passage through the superheater; by this means it is caused to flow for a considerable time over the hot plates. In the larger sizes the diaphragms consist of steel channels which are riveted to the side plates, these channels also acting as stays, whereas in the smaller sizes the diaphragms consist of steel plates carrying stout ferrules through which are passed the screwed and riveted stays binding the side plates together. Ample provision is made for examination and cleaning, there being an inspection hole at the top of every compartment excepting the end ones, which are provided with mud holes. As will be seen by reference to the illustration, the Simplex superheater (Lancashire boiler type) entirely dispenses with the flue-dividing wall, which is otherwise indispensable. Ordinarily without the dividing wall the

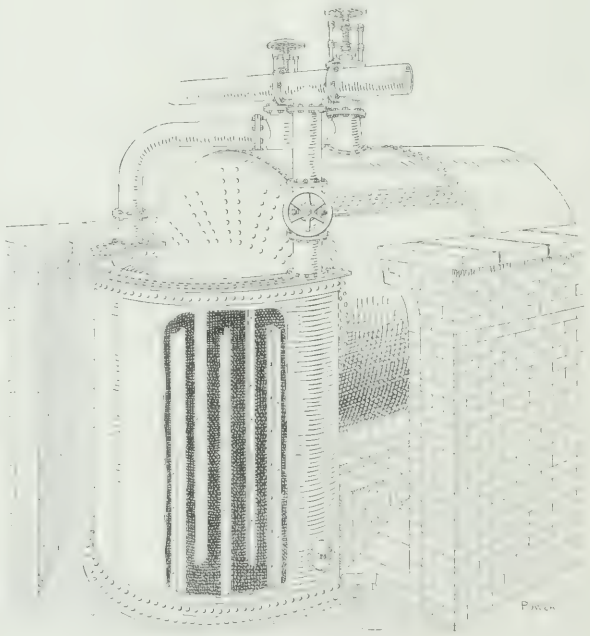


FIG. 7. SIMPLEX SUPERHEATER

hot gases would pass direct from the furnace into the main flue.

So far, the superheaters described have been discussed principally in relation to their place in the Lancashire boiler setting. The majority of them are equally adaptable to the water-tube type of boilers used in land practice, and, briefly, this aspect of the subject may be considered. In the Babcock & Wilcox boiler, for example, the type of superheater installed is so well known that it hardly needs any special description. It consists of a series of wrought-steel tubes bent to a U-shape and connected at both ends with manifolds, one of which receives the saturated steam from the boiler, the other collecting the steam after it has traversed the superheated tubes and delivering it to the valve placed above the boiler. The superheater is placed at the rear of the boiler above the boiler-heating tubes, where there is practically no deteriorating effect of the furnace gases and where the temperature is sufficiently high to raise the steam through 100 or 150 degrees Fahrenheit of superheat, or more if desired. On the Continent a superheat of 250 to 260 degrees Fahrenheit is often employed in connection with these boilers, by increasing the size of the superheater. Prevention against overheating during periods of steam raising is obtained by flooding the tubes with boiler water, using the superheater as part of the boiler-heating surface. The flooding arrangement consists of a connection with the water space of the boiler drum and two cocks. By the larger of these the water is allowed to enter the lower manifold, filling the superheater to the boiler-water level. Any steam formed in the superheater tubes is returned to the boiler drum through the collecting pipes which, under normal conditions, convey saturated steam to the upper manifold. Before opening the superheater stop valves and using saturated steam, the water is drained away from the manifolds by the flooding pipe and the smaller cock, a sight-glass being attached to the drain outlet in order to see when all the water has been drawn out of the superheater.

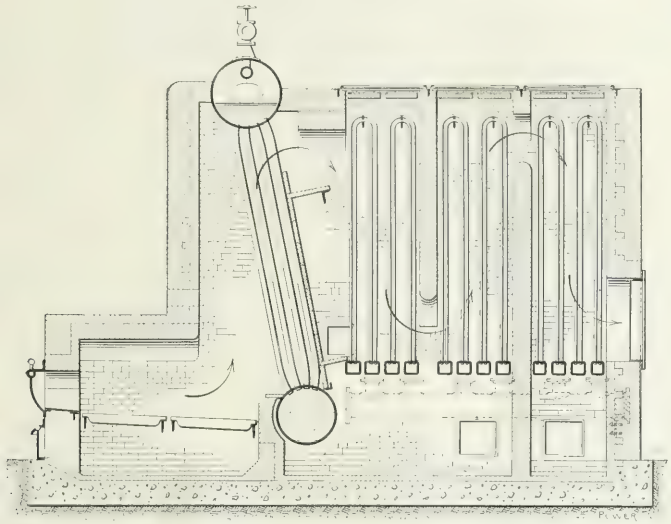


FIG. 8. STIRLING INDEPENDENTLY FIRED SUPERHEATER

INDEPENDENTLY FIRED SUPERHEATERS

It now remains to deal with the use of independently fired superheaters. These may be employed with any form of fuel, either coal, oil or gas. In addition to the uses in the power house, steam superheated in this way has been utilized in connection with the chemical industries, glycerin making, asphalt reduction, wood preservation, and evaporating, drying and heating installations of all descriptions, with a marked degree of success. Some interesting installations of independently fired superheaters are to be found in Great Britain in connection with large steel works. At the works of David Colville & Sons, Ltd., of Motherwell, Scotland, three sets of independently fired Watkinson superheaters, each dealing with 130,000 pounds of steam per hour, are used in connection with the steam supply to the rolling-mill engines. It has been found that when working with superheated steam the engines for rolling heavy plates get away much quicker, and a plate which with saturated steam occupied 4½ minutes could be rolled in 2½ minutes with superheated steam.

The ordinary design of independently fired superheater is very simple, the tubes being placed over a grate; and interposed between the grate and the tubes proper are brick baffles and cooling devices to keep the temperature of combustion at the lowest possible point.

STIRLING SUPERHEATER

In the Stirling independently fired superheater, shown in Fig. 8, a boiler element is introduced between the grate and the superheater proper. The temperature of the gases is lowered to about 1300 deg. F. before leaving the boiler section, so that overheating of the superheater tubes is thus avoided.

BABCOCK & WILCOX SUPERHEATER

Although, in the adoption of superheating, the Babcock & Wilcox Co. prefers to make the superheater a part of the boiler, there are certain cases in which it is necessary to use a separately fired superheater, such as where the arrangement of the boiler setting and steam pipes is such as will not admit of con-

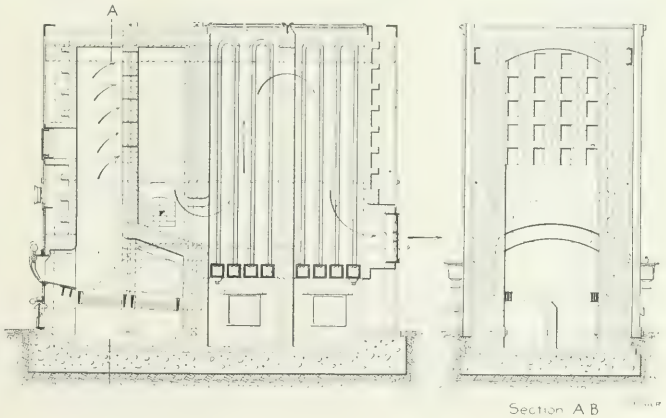


FIG. 9. BABCOCK & WILCOX INDEPENDENTLY FIRED SUPERHEATER

structing superheaters to form part of the boiler proper without stopping the works, or making costly alterations in the steam pipes, where it is desired for some particular purpose to superheat steam passed through an engine that has been exhausting at a pressure of 50 to 60 pounds, such as, for instance, in sugar refineries, and also for testing engines, etc. The Babcock & Wilcox patent independently fired superheater has a heating surface consisting entirely of extra-heavy vertical seamless tubes of 1½-inch outside diameter. The superheater has no screwed connections, all the tubes being expanded and bell-mouthed into holes drilled in the wrought-steel collectors. The steam enters the main connecting pipe and thence is distributed into the horizontal manifolds which connect with it. These manifolds are interconnected by double U-tubes, and with each other, in such a manner that a thorough circulation of the steam is obtained, the steam being eventually collected again in the collecting pipe. The furnace contains an ordinary grate and, in order to avoid the direct impingement of the flames on the tubes, it is practically constructed as a gas furnace. The gases enter a muffling chamber through a perforated wall, by which means an equal temperature can be obtained, whence they pass into the superheater chamber proper. After having passed through the superheater-tube chamber, around the brick flame baffles, the gases pass through the damper (which also regulates the combustion of the fuel) into the main flue. The superheater is fitted with a safety valve, a pressure gage, a dial thermometer and a drain valve to run off any condensed water that may have collected during the stoppage of the superheater. Fig. 9 shows one of these superheaters recently supplied to a large British power plant.

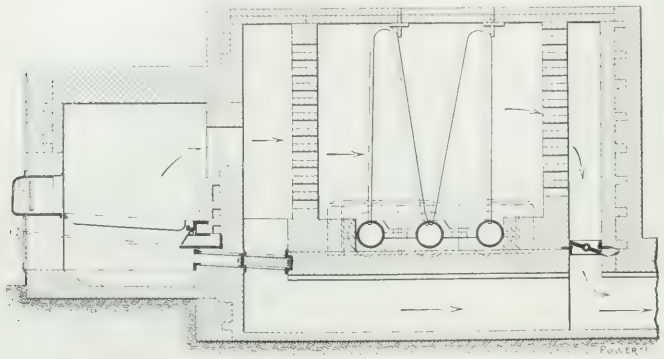


FIG. 10. WATKINSON INDEPENDENTLY FIRED SUPERHEATER

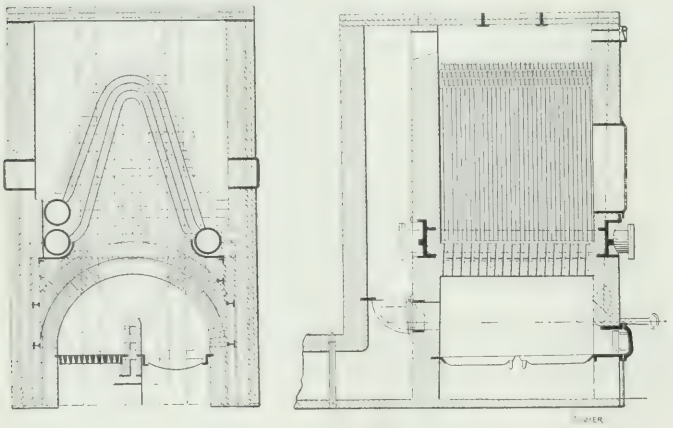


FIG. 11. MODIFIED FORM OF WATKINSON SUPERHEATER

WATKINSON SUPERHEATERS

One arrangement of the Watkinson independently fired type of superheater is shown in Fig. 10, the degree of superheat being regulated by the damper at the rear. A bypass damper and flue are also provided, so that during steam raising the products from the superheater furnace do not pass over the tubes of the superheater. The perforated firebrick walls through which the gases pass act as heat reservoirs and maintain the temperature of the gases when the furnace doors are open, while the brickwork takes in heat during the periods of most rapid combustion and thus acts as a regulator of the temperature of the gases supplied to the superheater.

Another successful arrangement of the same superheater is illustrated in Fig. 11. This type has the advantage in that it requires much less floor space than most other types. The furnace is placed below the superheater, the products of combustion rising through a perforated firebrick arch which acts as a gas distributor and heat regulator. In the case of these separately fired superheaters, the temperature of the products of combustion leaving the superheater is from 120 to 150 degrees Fahrenheit above the temperature of the steam entering the superheater, when the weight of the products of combustion is 24 pounds per pound of coal. The thermal efficiency of the superheater varies from 65 to 75 per cent.

A most important feature of this superheater is that all the tubes can be completely drained, and, owing to the tubes being almost vertical, there is not the same accumulation of soot and ash upon them as in the case of horizontal tubes.

Saving Fuel with Low Pressure Turbines

An example of operating advantages and actual saving in fuel consumption effected by the passing of steam from Corliss engines through low-pressure turbines is reported from a large Eastern chemical factory. The owners of this plant, which was being operated partly by shafting and belting from an old engine and partly by motors on current from two engine-driven electric units of 500 kw. capacity each, provided for an increase in capacity by installing two low-pressure turbines and direct-coupled generators also rated at 500 kw. each.

As the first result, the old engine was disconnected and the entire plant given over to motor drive. At present the two cross-compound engines and one low-pressure turbine are being operated on the day run and one engine and turbine on the night run.

Writing to an engineer who had assisted in laying out the enlarged plant, the owners stated that during the four days previous they had saved 55 tons of coal compared with the former consumption per unit of power. They had also begun the systematic keeping of a power log and felt that when they became better acquainted with the turbines they would be able to show still greater economy

Wire Rope Splicing

By F. L. Johnson

Wire rope is susceptible of almost perfect splicing and the operation is so simple that it may be learned in an hour by any mechanic who is at all skillful with the use of ordinary tools. For all kinds of transmission rope the long splice is used and should not be less than 16 feet in length for ½-inch rope and increasing to 30 feet for the larger sizes.

Where the splicing must be done in position, rope blocks are used to draw the wire rope taut, as in Fig. 1, care being taken to make fast far enough from the ends to leave plenty of room for the splice and the men who make it. If possible, it is better to hold the rope taut, mark the splice on both ends, by securely winding with No. 20 annealed-iron wire, throw it off the sheaves and make the splice on the floor or staging, as may be most convenient.

The strands of both ends are unlaid, back to the points wound with wire, the hemp core cut off and the ends brought together with the strands interlaced, Fig. 2. Any strand, as *a*, is unlaid and closely followed by the corresponding strand 1 of the other end of the rope which is pressed closely into the groove

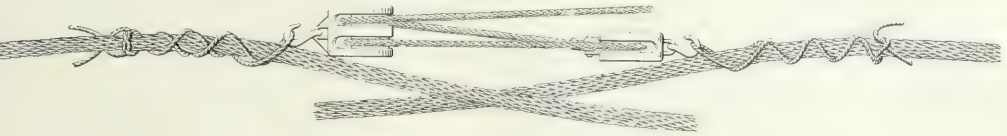


Fig. 1.

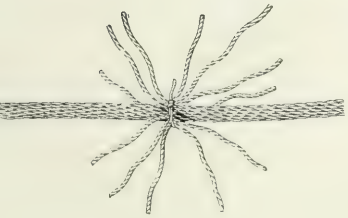


Fig. 2.

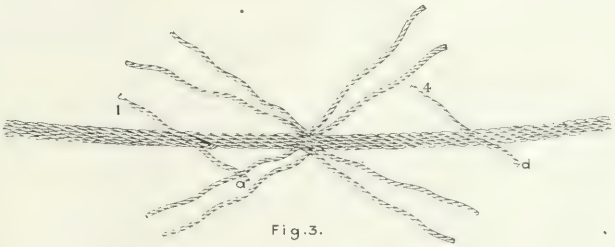


Fig. 3.

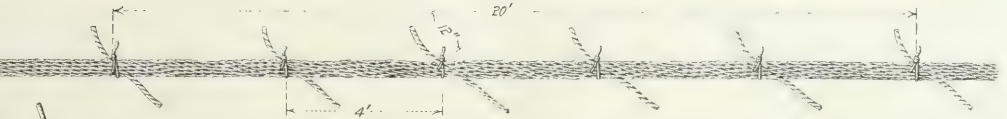


Fig. 4.

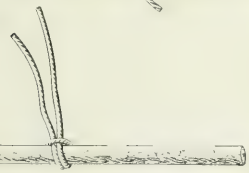


Fig. 5.

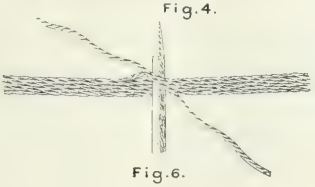


Fig. 6.

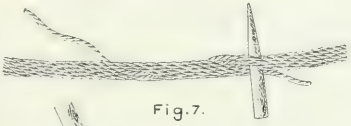


Fig. 7.

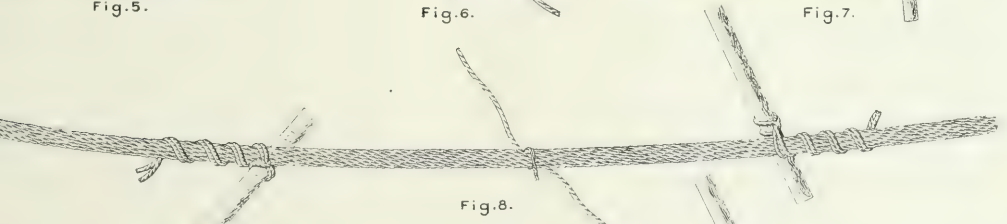


Fig. 8.

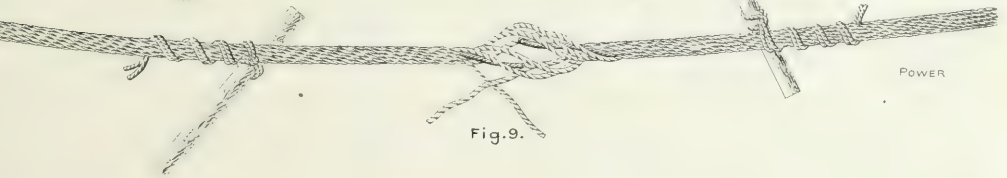


Fig. 9.

left by the unlaid strand. The unwinding of one strand and the inwinding of the other are continued until all but about 12 inches of strand 1 is inlaid, when *a* is cut off at the same length with a sharp chisel. See Fig. 3. Strands 4 and *d* are next treated in the same way and the process is repeated with each pair of strands until all are laid and cut as in Fig. 4.

Around each point where the free strands cross, a few turns of stout twine are made and the length of the splice is bent and worked in all directions until the tension in all the strands is equal and the rope as flexible there as elsewhere. If this is not done and there is more tension in some of the strands than in others when a stress is put on the rope, these strands will pull into the rope, making a bad-looking and weak splice.

Next, the open or free ends of the 12 strands are carefully trimmed and served or wound with fine wire, and two rope and stick clamps, Fig. 5, are secured to the rope, one on each side of an end crossing, as in Fig. 8, for the purpose of aiding in tucking the strand ends into the middle of the rope.

There are two ways of tucking in these ends. They are first straightened with a mallet. The long ends of the rope-clamp handles are twisted in opposite directions, separating the strands and exposing the hemp core, which is cut off and pulled out between the points to where the tucked-in strands will reach and the ends forced into the place formerly occupied by the core.

This is most easily done with the aid of a marine spike, which is passed over the strand which is to be tucked and under two strands of the rope, Fig. 6, and moved along the rope spirally following the lay and forcing the free end into the core space, Fig. 7.

In the other method the strands are more widely separated by untwisting the rope with the clamps, Fig. 9, slipping the free end in between the strands and correcting slight kinks by the use of a mallet.

The order in which the ends are tucked in is immaterial. Some operators prefer to tuck all the ends pointing in one direction before any of those pointing the opposite way, while others finish each pair of ends in series.

If the foregoing directions are intelligently followed the splice will be uniform with the rest of the rope, of nearly equal strength throughout, and after a few hours' use it will be almost impossible to detect the splice.

Any operator who is satisfied with what he is doing, says *Coal Age*, has reached his culminating point—he will progress no more. Too often we mistake movement for improvement. The measure of progress is not the ground passed over, but the gain in passing.

Connecting Rod Ends

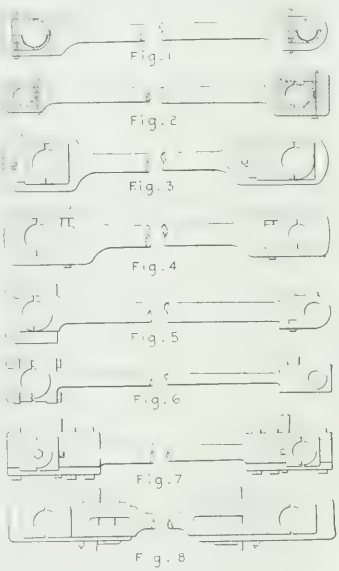
By J. A. Levy

It is interesting and instructive to notice the type of connecting-rod ends, used by the different engine builders, and the materials used in their construction.

Referring to Fig. 1, it will be seen that one wedge is between the pins and the other on the outside.

With this design, taking up the wear on one end lengthens the rod, while taking up on the other shortens it, and it will keep the rod of constant length, if the wear on the boxes is equal, but for the reason that the wear is greater on the crank end, allowance must be made. When the end box on the crosshead end is semicircular in form it is usually held in place by a setscrew in the end of the rod.

In Fig. 2 the wear is taken up by



drawing the wedge up from the bottom, the exact opposite of Fig. 1. In Fig. 3 the wear is taken up by drawing the wedges in from the side.

The rod ends thus far considered have been designed with a view to keeping the rod of practically constant length, but the rod shown in Fig. 4 introduces a new feature. Both wedges are between the pins, and taking up the wear by drawing the wedges up has a tendency on both ends to lengthen the rod.

The rods shown in Figs. 5 and 6 are both for center-crank engines, the crank end consisting of two halves bolted together, with shims between the parts to allow for making adjustments and taking up the wear, until, when the limit of the shims is reached, it becomes necessary to rebabbitt the parts and replace the shims. The crosshead end of one of these rods is of the solid-end type with wedge adjustment, while that on the other engine is of the open-end type, with strap and key adjustment.

The rod shown in Fig. 7 is of the open-end, strap and key type, consisting of two steel straps bolted together, the bolts passing through the rod. The ends of the straps are held together by another bolt with a steel distance block between. Setscrews aid in holding the keys rigid. The rod shown in Fig. 8 presents some very interesting features. It is of the open-end type, with strap, gib-and-key adjustment. The strap is prevented from spreading by a bolt which passes through the rod. The bolt is a snug fit at both ends where it passes through the strap, but the hole through the rod is enlarged, as shown by the dotted lines, thus allowing for making adjustments. The strap is also tied near the ends by the V-shaped impressions in the ends of the gib, which engage the corresponding projections on the strap. The gib and key are only about one-half the thickness of the strap, which is slotted out to receive both. The portion of the gib inside the strap has no bearing on the rod, and the straight side of the key does not bear on the strap (see dotted lines), so that when driving the key the bearing is from the end of the rod against the butt box, on the one side, to the gib bearing on the V-shaped projection on the strap at the other side, the result being to pull the rod and butt box back toward the pin, and draw the strap on over the rod, thus drawing up the end box. This applies to both ends of the rod. Setscrews hold the keys from moving up, and thus working loose.

It will be well to get thoroughly familiar with the peculiarities of this type, because the location of shims in this rod end is a pet question with several of the examiners. Referring to Fig. 4, it was said that taking up the wear lengthened the rod, because both wedges were between the pins, but in Fig. 8, in spite of the fact that both keys are between the pins, the center-to-center distance between the pins is shortened by driving the keys, as will readily be seen by a study of the figure and accompanying explanations. Some builders use this same type of rod end on the crosshead end of some of their engines, taking advantage of this form of construction to produce a rod designed for constant length, compensating by using on the crank end a solid-end rod with a wedge adjustment inside the pin, which tends, when taking up the wear, to lengthen the rod.

There is little to be said regarding the comparative merits of the various types, as each represents a great number in use, giving satisfaction, and each has its advocates who are able to advance arguments in its favor.

Initial Cylinder Condensation

Abstract of paper read before the Institute of Engineers and Shipbuilders in Scotland by Prof. Mallanby, and the discussion following its presentation.

At a recent meeting of the Institution of Engineers and Shipbuilders in Scotland, considerable interest and much discussion were occasioned over a paper by Prof. Mellanby upon the initial condensation in steam-engine cylinders. The difference between the actual steam consumption and that indicated by an indicator diagram was popularly termed the "missing quantity."

Prof. Mellanby's contention was that the initial condensation in a steam cylinder at admission and the reëvaporation during expansion are not as great as is generally supposed. Admitting, however, that some does occur, he explained that the amount must depend altogether upon the temperature of the metal itself.

Assuming that the temperature changes in the steam engine cylinder follow approximately the simple harmonic law, the following formula was applied:

Heat absorbed per square foot per cycle $= \frac{2T}{N}$ *B.t.u.*

where

T = Temperature range in degrees Fahrenheit;

N = Cycles per minute.

Citing some results obtained by Messrs. Callendar and Nicolson in temperature measurements upon an engine running at 73 r.p.m. in which the following were obtained,

	Max	Min	Mean	Range
Temperature of steam, degrees Fahrenheit	324	212	245	112
Temperature of cylinder metal, degrees Fahrenheit	304 4	297 6	301	6 8

Prof. Mellanby pointed out that the temperature range in the metal of 6.8 deg. applied to the foregoing formula would account for a very small amount of initially condensed steam.

Another formula for the heat absorbed by the cylinder walls (based upon Messrs. Callendar and Nicolson's work) was given.

In this the heat given out by the steam per square foot per second is taken as

$$0.74\ (T - \Theta)\ B.t.u.$$

where

T = Temperature of steam;

Θ = Temperature of metal.

The belief was expressed that a thermometer inserted in a hole in the cylinder would give the average temperature of the metal and that the indicator diagram would show the steam temperature, thus giving the quantities necessary for the solution of the formula. The following experimental data were given from measurements on the high-pressure cylinder of a compound engine.

		No Jackets	Jacketed
1.	Steam used per hour, lb.	2184	1980
2.	Indicated weight at cutoff, lb. per hour	1431	1470
3.	Indicated weight at release, lb. per hour	1781	1760
4.	Difference between actual and indicated weights, at cutoff, lb. per hour	753	510
5.	Difference between actual and indicated weights, at release, lb. per hour	403	220
6.	Increase of indicated weight between cutoff and release, lb. per hour	350	290
7.	Mean temperature of clearance surface, deg. F.	335	342
8.	Mean temperature of steam, deg. F.	284	282

These trials are to some extent illustrated by the accompanying diagram in which temperatures have been substituted for the usual pressure ordinates, these temperatures being plotted on the

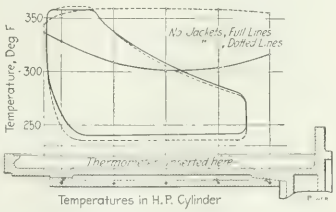


DIAGRAM SHOWING TEMPERATURE OF METAL AT DIFFERENT PARTS OF STROKE

assumption that the steam is always at saturation temperature during the stroke. On the same scale the average temperature of the metal along the cylinder is shown. The temperatures were obtained by thermometers inserted in the metal at the points marked by the circles. As would be expected, the jacketing has raised the temperature of the metal very considerably.

Line 4 in the foregoing tabulation shows that in the engine without jackets there was an apparent initial condensation of 753 lb. per hour, and that the application of the jackets reduced this to 510 lb. per hour. The apparent reevaporation between cutoff and release is shown in line 6 to be 350 lb. per hour for the unjacketed, and only 290 lb. per hour for the jacketed cylinder. That is to say, the hotter the walls the less readily will the water on them be evaporated. It is obvious that these figures cannot be explained on the initial condensation theory. The actual amounts of initial condensation, as estimated from the formula given previously, are, for the jacketed engine 114 lb. per hour, and for the unjacketed 80 lb. per hour. The remaining part of the difference between indicated and actual weights is to be attributed to valve leakage.

Also in the unjacketed trial the maximum temperature of the steam was 356.5 deg. F., and the mean temperature of the metal 335 deg. F. The greatest possible range of temperature in the metal could not be, therefore, more than

$$2\ (356.5 - 335) = 43 \text{ deg. F.}$$

Assuming this range, and using the formula for the heat absorbed during periodic temperature changes, it is found that under these conditions the steam initially condensed per hour would be 557 lb. The actual weight of steam to be accounted for was 753 lb. per hour, so that even if the smallness of the actual temperature range were not known from Callendar and Nicolson's work, and the excessive range given be assumed, the initial condensation theory apparently breaks down.

Discussion

Prof. Mellanby's paper provoked much adverse criticism, some of which is herewith given:

R. M. Neilson was of the opinion that little reliance could be placed upon the first formula cited by Prof. Mellanby as it did not take into consideration either the velocity or the density of the steam.

Referring to the deductions from applying the second formula, Mr. Neilson pointed out that it would be necessary to measure accurately the temperature range in the metal. He criticized Prof. Mellanby's method of measuring the temperatures of the metal by inserting thermometers at the places indicated, and showed that this would register a mean temperature between that at the top of the hole and that at the bottom, instead of the temperature of the metal surface with which the steam comes in contact. To emphasize this point Mr. Neilson submitted some calculations showing that for any depth greater than 0.1 in. below the surface the temperature range is very small.

Commenting upon Prof. Mellanby's assertion (with reference to the experimental data given) that "the reëvaporation in the case of the unjacketed cylinder is greater than in the case of the jacketed cylinder, which could not be the case if the missing quantity were accounted for by initial condensation," Mr. Neilson took just the opposite view, pointing

out that there is less steam initially condensed when the cylinder is jacketed because the cylinder walls are hot, hence there is very little condensation on the cylinder walls. Consequently the re-evaporation is less because the condensation on the cylinder walls, being small, evaporates soon after cutoff and the evaporating surface is then limited to the surfaces of the piston and the steam ports.

Following Mr. Neilson, Mr. James Andrews took up the discussion. He asked where the thermometers were placed in Prof. Mellanby's engine. If the cylinders were horizontal and the thermometers were placed at the top of the cylinder, then he considered they would not indicate the temperature at the bottom of the cylinder. This was owing to the tendency of water to lie at the bottom of the cylinder. Referring to some tests made by himself as to the missing quantity in different engines, in which a tandem engine was compared with a cross-compound engine, he found that the missing quantity with the tandem engine was 49 per cent. in the high-pressure cylinder and 28 per cent. in the low-pressure cylinder, while with the cross-compound engine the missing quantity was 25 per cent. in the case of each cylinder. The steam when admitted to the high-pressure cylinder was dry in both cases. Mr. Andrews further contended that the time element had an important influence on the missing quantity. In one test which he carried out he found that, after the engine had been running eight hours, the missing quantity was 8 per cent. less in the high-pressure cylinder and 7 per cent. less in the low-pressure cylinder than was the case after the engine had been running only two hours. He also found that the speed at which the engine ran affected the missing quantity.

Mr. Andrews compared the results obtained by different experimenters as to valve leakage and remarked on the great disagreement between them. Referring to the wear on slide valves, he recalled a case in which ⅜ in. was worn off a locomotive slide valve in four months. With the valve pressed so hard against the face of the cylinder as to produce this wear he doubted if a film of water could exist between the valve and the cylinder, as is said to be the case by those who advance the valve-leakage theory.

Mr. C. A. Matthey confined his remarks to an incidental remark of Prof. Mellanby to the effect that during compression the steam was everywhere superheated, slightly in the main body, more near the walls, and most of all in a small pocket.

As pointed out by Mr. Matthey, steam remaining in the cylinder when the exhaust port closes is compressed to initial pressure either by the piston or partly by the piston and partly by the incoming steam. In many noncondensing engines such compression is effected entirely by the piston; and if, as Prof. Mellanby had stated, the steam and cylinder were dry at the commencement of compression, the steam was necessarily superheated during the whole of compression, and finally attained a temperature far higher than that of the initial saturated steam.

If dry saturated steam were expanded adiabatically, it would follow the law

$$PV^{1.35} = C$$

part of it being condensed. If this steam and water were compressed, it would follow the same law, and retrace the original expansion curve, till on arriving at the original pressure, its original volume and original temperature would be also established.

But if, after the steam was expanded to the lower limit of pressure, the water formed were removed, either by evaporation or by being swept out by some means, then upon compression the dry steam remaining would follow a different law, namely,

$$PV^{1.13} = C$$

and the temperature would rise much more rapidly than in the other case; the relation between pressure and temperature being

$$\frac{T}{t} = \left(\frac{P}{p}\right)^{\frac{0.3}{1.3}}$$

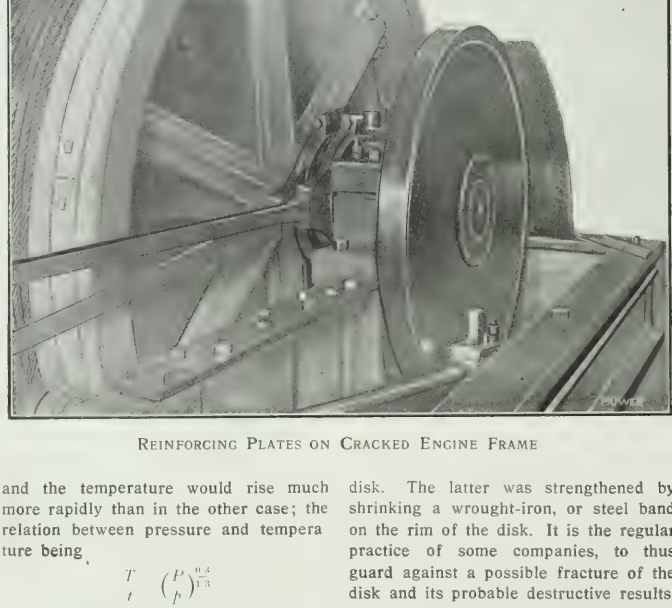
where T and t represent the upper and the lower absolute temperatures, and P and p the upper and lower absolute pressures.

Mr. Matthey cited an ordinary example from which, applying the formula, T was found to be over 600 deg. F. He then questioned if anyone of the "leakage" school had ever seen such temperatures recorded at the end of compression under these circumstances. Or, since it would not be reasonable to expect the full temperature, because, owing to the conductivity of the metal, the compression was not purely adiabatic, had they ever seen 500 degrees?

If they had not, it pointed to the presence of water, whose power of cooling when evaporating and absorbing latent heat was very great: but if they had then through the greater part of compression the steam was hotter than the metal and was giving up heat to it; consequently the steam next to the walls would be cooler than that more remote, and the steam in a small pocket would be coolest of all.

Light Engine Frame Fractured

The early types of hoisting engines were made extremely light, both in the bed and in crank-disk construction. The first frequently resulted in a fractured bed and the second in a cracked crank-disk. The latter was strengthened by shrinking a wrought-iron, or steel band on the rim of the disk. It is the regular practice of some companies, to thus guard against a possible fracture of the disk and its probable destructive results.



Reinforcing Plates on Cracked Engine Frame

In one instance, the frame cracked just inside of the pillow block and at the outside corner. The illustration shows how the bed was strengthened. On the

inside of the main pillow block a piece of 1-in. iron plate, 7 in. wide was bolted against the base of the bearing and secured to the frame by ten 1-in. bolts. A similar plate was bolted in like manner to the frame on the other side of the bearing.

The cracked corner was reinforced by a piece of ⅜ in. iron bolted in place, as shown. To act as a safeguard against further cracking of the bed a reinforcing piece was bolted to the inside of the frame directly over the crack.

Across each end of the frame cross-rods were placed through which 1 ¼ in. through-rods were run and the nuts screwed up tight. This engine has been used on slope work for years.

Heat Transmission

At the recent meeting of the American Society of Mechanical Engineers, George A. Orrok contributed to the work of the research committee the following résumé of present knowledge of the laws governing heat transmission, including the results of his own researches:

The present state of knowledge of the laws governing the transmission of heat through metallic tubes from gases and liquids to gases and liquids is that it takes place in at least three separate operations—the transfer from the warmer fluid to an initial surface of the tube; the heat passage through the tube wall from the warmer surface to the cooler surface of the tube, and the transfer from the secondary tube wall to the cooler fluid. This has been expressed by the general equation of Peclet:

$$\frac{1}{k} = \frac{1}{c} + \frac{1}{q} + \frac{1}{r}$$

where k is the coefficient of heat transmission.

The quantity q depends on the thermal conductivity of the tube which is now known quite accurately:

$$q = \frac{K_t}{D}$$

D = Thickness of tube;
K_t = A constant depending on the material.

r (following Osborne Reynolds) $= \frac{d_w V_w}{B}$

or, following Josse,

$$r = 510 \sqrt{V_w}$$

where
d_w = Density of the cooling fluid;
V_w = Velocity of cooling fluid;
B = A constant.

c (following Pickworth and Nicholson)

$$= 1.2\ V_s + 29{,}400\ d_s - 305$$

an empirical formula where V_s is the velocity of the hotter fluid and d_s its density.

The quantity q is always very large as compared to c or r; so much so that it can be neglected in practical problems; in other words, the heat-transferring capacity of metallic tubes is always largely in excess of the heat which can be brought in contact with the tube surface. For this reason it is much more convenient to use a simpler expression, such as

$$K = C \sqrt{V_w}$$

Fourier stated the law as follows:

$$dH = K\ S\ dz\ (T - t)$$

where
S = Surface;
z = Time;
T and t = Temperature.

When S and z are unity, this expression becomes:

$$H = K\ (T - t)$$

and $(T - t)$ corresponds to Θ_m in our modern expression. H equals N, the total heat transferred, and

$$N = K\Theta$$

$$N = C \sqrt{V_w}\Theta$$

which is the form commonly used today.

Determination of Heat Transfer

There are many practical problems connected with the determination of the laws of heat transfer. Some of the more important being:

The transfer from flue gas to water under the conditions existing in economizers. Here the transfer is of the order of 2 B.t.u. per square foot per hour per degree difference of temperature;

The transfer from flue gas to boiling water under boiler conditions (feed water heated to steam temperature). Here the transfer is of the order of 10 B.t.u. per square foot per hour per degree difference of temperature;

The transfer from flue gases to steam or air under superheater or air-heater conditions. This transfer is of the order of 4 B.t.u. per square foot per hour per degree difference of temperature;

The transfer from hot air to colder water under air-cooler conditions. This is of the order of 4 B.t.u. per square foot per hour per degree difference of temperature, and

The transfer from condensing steam to water under surface-condensing conditions. This is of the order of 1500 B.t.u. per square foot per hour per degree difference of temperature, when no air is present but falls off to from 500 to 600 B.t.u. when an ordinary amount of air is present.

There seems to be an essential difference in the action when a condensible gas or vapor is the high-temperature fluid. Here the vapor gives up its latent heat to the colder tube and contracts enormously in condensing, causing an exceedingly rapid flow normal to the tube. It may be that an analogous action takes place when the colder tube is exposed to the "bombardment" of radiant heat as in the case of boiler tubes exposed to the rays from white-hot surfaces of fuel or brickwork.

Prof. Bone, in his lecture before the Royal Society last year, stated that he had obtained in an experimental boiler an evaporation as high as 41 lb. of water per square foot of surface which corresponds to approximately 25 B.t.u. per square foot per hour per degree difference. This was due to the radiant heat condition.

Probably the best exposition of the problem where a permanent gas is the hotter fluid is given in Prof. Dalby's report to the Institution of Mechanical Engineers (Oct. 29, 1909), and his conclusions (summed up on pages 25 to 28) show the exceedingly difficult nature of the problem and the necessarily costly means which must be used for its complete solution. The main factor is the determination of the temperature gradients in all parts of the boiler. That this is also true of condenser conditions may be seen from the work of Smith and Josse and the author's paper before this society last year.

"Mass Flow" Theory

The "mass flow" theory of Osborne Reynolds and Jordan seems to be another form of stating the fact that where more heat is present more is transmitted and this is known to be true up to the limit of heat transfer. Kreisinger and Ray have investigated this problem with an experimental boiler using air heated electrically as the hotter fluid, and their results have been widely quoted. The work of Perry, developed by Breckenridge in Bulletin 325 of the Geological Survey, is also of great value in this connection.

Summary

Summarizing, the lines of work which will be most fruitful are as follows:

1. A final determination of the radiant-heat law (Stefan's law) with a separation from conduction and convection problems. It is probable that Stefan's law is nearly correct, but does the black-body condition exist, and between what ranges of temperature? Bone's experiments seem to show that it may exist at temperatures below red heat. (See Bulletin No. 8, Department of Mines.)

It is known that in boiler conditions radiation is much more efficient than either conduction or convection. How much of the heat supply can be developed as radiant energy? Both Nicholson and Bone claim that the boiler of the future will depend largely on radiation rather than conduction.

2. More study of the phenomena of heat transfer in the absence of radiant energy, if this is possible. What is the effect of dust and soot in the gases? Do the dust particles act as black bodies and give out radiant energy? It has

been stated that 98 per cent. of the temperature drop took place in the passage of the heat from the gas to the tube surface. Is this statement correct and, if so, can the "gas film" be removed or made a better conductor?

3. Determination of the temperature gradient under a variety of practical conditions, and with full-size apparatus. Does the "gas film" give more trouble when inside a fire tube with axial flow of gases or when outside a water tube with a flow across the surface?

4. A determination of the law of temperature rise in the water flowing in a condenser tube. The tube should be long and the thermometers numerous.

5. A repetition of Smith's experiments with the addition of known amounts of air and with the use of very sensitive thermometers. This series should include all commercial vacuums, and the lower end of the steam table should be recalculated with much smaller intervals for use in interpreting the results.

6. The author has used the expressions "radiant heat," "latent heat," etc. Sensible heat is defined as molecular motion, radiant heat has been defined as "ether waves." When latent heat is set free as in a condenser, is it molecular or ethereal in its constitution? In chemistry, there is a state known as the nascent state existing when an element is set free from combination. Does an analogous action take place when heat is set free from the latent state?

Some of these questions should be perhaps answered by the physicist rather than the engineer, but in the author's opinion they are true engineering problems and must be studied through their applications if a complete, reasonable and satisfying theory is to be obtained.

Boiler Explosions in England

By William H. Booth

The treatment of boiler explosions in England has often been described as locking the stable door after the steed has left it. To inquire into a boiler explosion after the event is, on the face of it, inferior to the German governmental attempt to prevent explosions. Moreover, to hold a solemn inquiry into such happenings as the fusing of a fusible plug—which it is said has been at least once classed as an explosion—savors of the ridiculous. In England there is no governmental or municipal control of steam boilers. There is a law that every boiler must be periodically inspected by a competent person, but there is no definition of the term, competent person.

In Germany the government does directly interfere to prevent explosions. In England a boiler owner may employ anyone he likes to do his inspecting, though he usually places his boilers in the hands of the boiler-insurance companies and leaves to them the selection of their own inspectors. Even then steam users are apt to regard the report as a certificate of safety and totally to neglect for years its recommendations.

Now what happens in this very English "muddling through"? First, our boilers are considerably safer than German boilers, a fact curious perhaps but true. And the inquiry after the fact has undoubtedly much to do with it.

Inquiry after the Fact

Suppose an explosion takes place: There is an inquiry. Wigged barristers are then asking questions and bullying witnesses, as is the barrister's silly habit. Hundreds of silly questions are put to witnesses. The last inquiry I attended was concerning an explosion at Greenwich. I remember that a witness who was obviously speaking the truth, answered a question in a way all engineers present understood. The barrister, who perhaps had never seen a boiler in his life, was extremely rude to him, for he could not understand the answer and treated the witness as a rogue.

Somehow, a certain amount of truth is brought out—perhaps about a fourth as much as an engineer would get in a tenth of the time. Then comes the finding of the court. In the course of events I have seen a competent person charged or fined because he had no status to act as a competent person in boiler inspection. Possibly he was only a boiler-setting man or brick mason. I have seen an owner fined for employing the wrong sort of "competent person." Or he has been fined for neglecting to follow the recommendations of the boiler-insurance company; and again a boiler-insurance company has been censured and fined for continuing to insure boilers in face of the owners' continued neglect of its recommendations. The court sees the recommendation. If the recommendation is right and proper, it ought to have been insisted upon, they rightly argue. Chief engineers who have been electrical experts have got into trouble for assuming responsibility and therefore, by inference, knowledge of boilers they could not substantiate when called as witnesses.

Beneficial Effect of Inquiries

Costly as are these inquiries into explosions, they undoubtedly have a salutary effect on everybody concerned with boilers, for they lead to men putting onto paper their opinions as to the danger of a given boiler and thus bring to a focus on the proprietor the fact that it was his duty to remedy the danger. In a case under my own knowledge an engineer knew that the owner would say, "I trusted to my engineer." Yet that owner would not follow advice which, in daily contact, was passed verbally. So the engineer wrote a letter, copied it and sent it by registered post to the owner and thus effectively put the onus of a possible accident where it belonged.

The Board of Trade merely appoints a commission of inquiry, and if England's immunity from boiler explosions is greater than that of other countries, some of that immunity is possibly due to the greater freedom enjoyed by the owner to do as he likes, subject to an inquiry as to whether in the exercise of that freedom he has encroached on the freedom of others who are entitled to walk past a steam boiler in safety. It is, of course, open to the commission of inquiry to find that some person is guilty of manslaughter and in such an event the punishment after further trial might be severe.

Risk of Trial for Manslaughter

The risk of a trial for manslaughter must be faced by every boiler owner who neglects a serious report by a competent person. If the neglect continues long enough the onus may be shifted to the competent person, if such be an insurance company, for its neglect to treat the owner's neglect seriously; it may be urged by the owner in palliation of his own neglect, for he could well say, "If so serious, why did the company not refuse longer to insure the boiler?" If an owner employs an engineer who is fully empowered to do the right thing, yet neglects to do so, the owner would be absolved from blame.

The customary mode of fining consists in ordering a man to pay a certain sum toward the cost of the inquiry. It is not necessary that anyone should be either killed or injured; that an explosion has taken place is sufficient for a notification to be made. Little affairs are reported in a small way; more serious affairs are given a full-powered inquiry.

The only satisfactory, rational excuse for our method is on the principle of the proof of the pudding being in the eating thereof, for England does stand an easy first in the matter of boiler safety and minimum loss of life.

Used Gunpowder to Clean Flues

As the result of attempting to use a pint of gunpowder to clean the flues of a boiler connected to the hoisting engine used by the iron workers on the new Petroleum bridge at Oil City, Penn., the engineer is in the city hospital with his face and neck covered with burns and the possibility that the sight of one eye has been destroyed. He threw the gunpowder over the fire, expecting that the soot in the flues would be "exploded" out. The result immediately following such a rash experiment may be readily imagined.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Rewinding an Induction Motor Stator*

By R. H. Fenkhausen

Number of Coil Elements

Most induction motors contain coils of two or even three "elements," and as the form described in the preceding article is only adapted to single-element coils, it will be necessary to wind the elements

Fig. 11. Transferring to a Reel

separately. Forms can be made on which two- and three-element coils may be wound, but they are too intricate for industrial repair service, and have no advantage where the elements are connected in multiple. Where the elements are connected in series, the use of a two-element form obviates the use of internal soldered joints in the coil. This is only a slight advantage, as trouble from internal joints is practically unknown where they are properly located and well made.

As the designations "right" and "left" as applied to coils are purely arbitrary ones, the following rule will be useful: *Place the coil so that the terminals are toward the observer. If the "high" side of the coil is on the right, the coil is "right-handed."* By this rule, the coils shown in Fig. 14 are left-hand coils, because the high side of the coil is at the left.

It has become the standard practice of most motor builders to bring all the coil terminals out at one side of the motor, "right-hand" coils alone being commonly used. This allows a standard motor winding to be reconnected for several voltages, both two-phase and three-phase, and even for different speeds, upon removing only one end bell, without the rotor being disturbed. Changing the number of poles, of course, changes the ratio of coil pitch to full pitch, but, as explained in discussing fractional pitch, considerable latitude exists in this respect.

When a two-phase motor with standardized coils is to be wholly or even half rewound, the new coils may be wound so that the connections of the two phases are brought out at opposite ends of the motor, which greatly facilitates the tracing of connections when trouble must be located quickly.

Preparing the Magnet Wire

As the magnet wire necessary to make a set of coils is usually only a small part of a standard reel, this wire will be received from the supply house in the shape of an open bundle or so called "coil," in

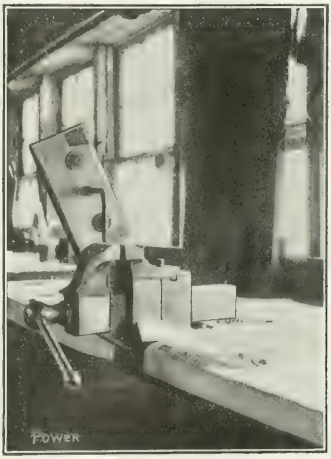


Fig. 12. Support for Coil Form

which shape it is utterly useless for coil-winding purposes, qwing to the liability of kinks and tangles forming while it is being used. A lineman's wire barrow with adjustable "stakes," or some equivalent device, may be used to hold the bundle of wire, but it will not give satisfaction because the tension required to turn the reel will pull the outer wires down between the inner layers of the bundle, from which they will pull out by jerks during the winding process. As every jerk puts a kink in the wire which must subsequently be straightened out, it is evident that a considerable loss of time will result.

Fig. 11 illustrates one method of disposing of this annoyance. The bundle of wire is placed on a wire barrow and the free end attached to an empty magnet-wire reel onto which the wire is transferred by turning the reel. The half-round groove in one flange of the reel is to accommodate a small leather brake strap fastened to the reel stand at one end and passing over the grooved flange. By attaching the proper weight to the free end, any winding tension desired may be obtained.

Supporting the Coil Form

Even if a lathe be available, the wisdom of using it to rotate the form is questionable, unless the winder's hands be left free by the application of some method of foot control. It usually takes a beginner much longer to shape the twisted ends of the coil than it does to shape the straight sides, so that even if a foot control is improvised, the uniform speed of the lathe will necessitate winding the whole coil at the slow speed required for the end connections, and the

Fig. 13. Winding an Element

varied character of industrial repair work seldom gives the winder an opportunity to become skilled in any one operation.

Fig. 12 shows a simple bent rod used as a mandrel by clamping the vertical portion in a vise at a height sufficient to clear the corners of the form during rotation. The form must be rotated by a boy, and it will be found that by watch-

*The first half of this article appeared in the issue of Jan. 9.

ing the winder the boy can accommodate the position of the form to the wire very easily. The time usually lost in clamping and unclamping the form in the lathe is saved and with a few hours' practice a set of 144 coil elements should be

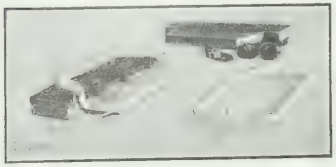


FIG. 14. READY FOR REMOVAL

wound by a man and helper in two eight-hour days.

WINDING THE COIL

A piece of soft flannel should be wrapped around the magnet wire to protect the winder's hands and the wire firmly gripped by the fiber clamp, care being used that an end is left beyond the clamp long enough to form the coil terminal. The form must then be rotated away from the winder by the helper until the required number of turns is in place, after which it should be slipped off the mandrel and the coil gently hammered into shape. While the coil is being shaped by the winder, the helper should prepare four little "hairpins" of No. 22 annealed copper wire which are to be slipped over the coil by way of the saw slots in the form and twisted up. These copper wire ties serve to hold the coil in shape after it is taken from the form, and care must be used not to twist them up tightly enough to damage the cotton covering on the wire. Fig. 13 shows the operation of winding and illustrates the formation of the "twist" by the winder's thumb. After the tie wires are in place the fiber clamp may be released, the form taken apart and the coil removed. Fig. 14 shows an open form with a coil ready to be removed. The tie wires are also

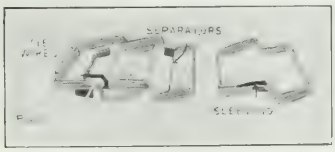


FIG. 15. NESTING TWO-ELEMENT COILS

clearly shown, and to the right a similar coil with the terminals shaped.

CONNECTIONS BETWEEN LAYERS

After the full set of coil elements and a few spares are completed, the next operation is the grouping of the elements into complete coils. Two stages of this operation are illustrated in Fig. 15. If the elements are to be connected in multiple, all four coil terminals will be carried outside the taping, but if a series connection is required an internal soldered joint should be made. It is possible to make the series connections outside the coil, but owing to space limitations it is not usually advisable, because it doubles the number of stub-end connections in the winding.

The choice between series and parallel coil elements often rests with the winder, as in the case of motor windings with interchangeable connections for 200 and 400 volts, as described in a previous article (see also the accompanying table of winding data). Take, for example, a motor having coils wound with two coil elements in series and the pole groups paralleled for 200-volt operation. If the winder so desires, the elements of each coil may be paralleled and the pole

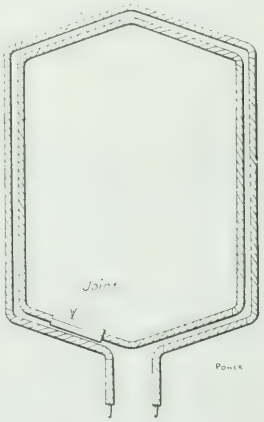


FIG. 16. RESULT OF WRONG ELEMENT CONNECTION

groups reconnected in series. This method will save considerable work and will do away with soldered joints inside the taping of the coil, but it should never be employed where there is any probability that the motor will be required to operate on the higher voltage. Before nesting the elements, thin fishpaper separators, long enough to extend well around the bends in the coil, should be inserted between the two parts of the coil, as indicated in Fig. 15. These give additional stiffness to the coil, preventing its collapse during the taping operation. The copper ties must be replaced with new ones encircling both elements and the coil terminals carefully bent into place. If series connections are to be employed, one terminal of each element must be cut off and the two connected. Before soldering the joint the outside terminals of the coil should be tried in series with a test lamp to insure that the series connections have been properly made. It is very easy to mistake the ends of the two elements, resulting in the condition represented in Fig. 16, and if the test lamp lights, indicating a closed circuit while the connection between elements is still open, the connections are wrong and only one element will be in circuit, the other being short-circuited.

If the coil tests all right, a short piece of sleeving should be slipped over one end of the joint and pushed back out of the way temporarily. Both terminals of the coil, as well as both ends of the series connection, should be carefully tinned with a nonacid flux, and a sleeve connector made of thin leaf copper soldered onto the joint. The short piece of sleeving may then be pulled snugly over the soldered joint and the coil laid aside for dipping, as shown at the right in Fig. 15.

The reason for beginning the coil on a certain side of the form can now be explained by aid of Fig. 17. The four possible locations of the joint are shown at *a*, *b*, *c* and *d*; *a* and *d* are both bad because the sleeve connector will come between the upper and lower groups of end connections, where it is liable to be forced through the taping by accidental blows, which tend to drive the end connections together. Location at *c* is bad because the sleeve connector causes a slight lump under the taping of the coil, which is very apt to be abraded while the rotor is being inserted. Location at *b* will bring all the connectors on the outside of the winding where they are out of harm's way, but will be plainly visible in case of trouble at the joint. A few experiments will show that in order to bring the joint at *b*, and still have a coil of the unsymmetrical type properly fitted in the slots, it will be necessary to place the starting clamp on the form exactly as described before.

DIPPING THE COILS

As soon as all the coil elements are nested they should be dipped in some form of insulating varnish, which will improve the insulation and cement the turns of the coil together. A baking varnish should be used if an oven is available,

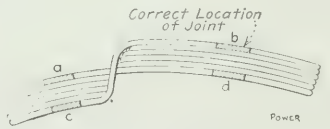


FIG. 17. LOCATION OF JOINT BETWEEN COIL ELEMENTS

but an air-drying varnish will give excellent results if the oven cannot be procured. The varnish selected must be nonsoluble in oil, nonhydroscopic, and preferably light in color, to facilitate the detection of partly charred insulation. Shellac forms an excellent dip, aside from its tendency to become brittle when thoroughly dry. A varnish which will remain semi-flexible is, of course, to be

preferred, other things being equal, but whatever varnish is selected, it should be thinned down so that it will readily penetrate between the various turns of the coil.

After the coils are removed from the dipping tank they should be hung up by one end and allowed to drain for a few minutes, after which they should be reversed, the bottom of the suspended coil becoming the top. This procedure insures a more even distribution of the varnish and allows the surplus which naturally flows to the bottom of the coil to flow back over the thin upper places in the coating. Besides the additional stiffness and improved insulation resulting from dipping the coils, it will also be found that dipped coils will run cooler than coils not so treated. This is probably due to the better heat conductivity of the varnish, which fills up all the spaces between the turns of the coil and allows the heat to be readily conducted to the surface and radiated.

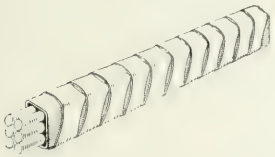


FIG. 18. DEFECTIVE TAPING

FIG. 19. REVERSE TAPING

FIG. 20. EFFECT OF TOO MUCH LAP

TAPING

After the coils are thoroughly dry they should be taped. The thickness and number of layers of tape used will, of course, depend on the operating voltage of the machine, the space available in the slot and the amount of slot insulation to be used. Enough insulation must be used on the coil to make it drive lightly into the slot, not tightly enough, however, to cause the coil to bend when it is removed by lifting both ends of the straight portion. If the coil is too tight it will be damaged by driving it into place; if too loose, it will vibrate when the motor is in service, and the insulation is apt to be destroyed. If two layers of taping leave the coil too loose and the layers make it too tight, the proper fit may be secured by the insertion of a thin paper filler between the fishpaper and treated cloth cells in the slots.

If the end connections are shaped so that there is a small air space between them when in place on the stator, one layer of cotton tape lapped one-half will give sufficient mechanical protection and the air space between the coils renders additional insulation unnecessary. If the shape of the end connections is such that adjacent coils fit snugly together, extra insulation will be required on the end coil of each group where the voltage exceeds 250. The voltage between adjacent coils of a group is only a small fraction of the motor voltage, but the end coils of each group are in contact with coils connected to the opposite phase and are subjected to the full differences of potential between phases. The additional insulation on these end coils is most readily applied in the shape of a layer of treated cloth tape, bound around the part of the coil lying outside of the slots, underneath the outside taping. For voltages exceeding 1100, the potential difference between coils is great enough to make double taping advisable on all coils.

The tape commonly used for the outer covering of coils is from ½ to ¾ in. wide and is composed of muslin webbing. The tape should be of open weave to allow the insulating varnish to penetrate readily into the interior of the coil, and should be cut on the bias for use on the twists and corners of the end connections, and cut straight for use on the straight portions (sides) of the coil. One kind of tape may be used for the entire coil when the size of the coil is small, but the results will not be as satisfactory. If straight-cut tape is used, it will be found that it is practically impossible to make a neat job of the end connections, and if bias-cut tape is used altogether, it will either lap over on the corners of the coil or stand open on the sides, due to the stretching of the weave, as shown in Fig. 18.

There are two ways of winding the required number of layers of tape on the coil. The first is to wind each layer separately and without lap, reversing the direction at the end of each layer, as shown in Fig. 19. The other method is to lap each layer the required amount; for instance, a one-half lap gives two layers, and a two-thirds lap, three layers.

Great care must be used when lapping the tape, that the required lap is not exceeded, because the thickest part of the coil determines the fit in the slot, and even a $\frac{1}{32}$-in. lap over the necessary amount will give to the coil the effective thickness of an additional layer of tape, as shown exaggeratedly in Fig. 20.

SHAPING THE COILS

After the coils are all taped, the end connections must be bent to conform to the curve of the stator bore, as shown in Fig. 21. The coils are wound with the sides parallel and as the slots are all radial, they must be bent at the proper angle to lie in the slots. It will be found that the proper angle between the straight parts of the coil will result naturally from the curving of the end connections shown in Fig. 17, which may be given to the coil by bending over the thumbs of the two hands, except with very large coils, which require a press. After the coils are shaped they should again be dipped in insulating varnish, and when thoroughly dry the straight sides, which will lie on the slots, must be pressed between a pair of fiber blocks, clamped to the jaws of a vise. These blocks should be grooved to receive the coil, as shown in Fig. 22, the grooves being each one-half as deep as the width of the slot with all the insulating cells in place. Considerable pressure may be applied to the coil without causing any damage, because the fishpaper separators placed between the layers of the coil prevent the turns of one layer from being forced between the turns of the other layer, and coils having absolutely uniform thickness will result and materially aid their insertion into the slots.

MAKING THE CELLS

Most of the slot insulation ordinarily employed is for mechanical strength, and a comparatively small amount would suffice were it not for the liability of damage due to high laminations, etc. Most of the space available for insulation is therefore occupied by a cell of very tough fibrous paper about 10 mils thick, known to the trade as leatheroid or fishpaper, and having a breakdown resistance sufficient to withstand almost 2000 volts. The cells of this material should extend about ¼ in. beyond the iron and should be a trifle below the top of the teeth when in place.

An additional factor of safety is usually given to the insulation by inserting a cell of varnished cloth or treated cambric between the leatheroid cell and the coil. This material has a breakdown voltage of 1000 volts per mil, and when used in places protected from mechanical injury, such as inside cells, renders a motor practically immune from breakdowns due to faulty insulation.

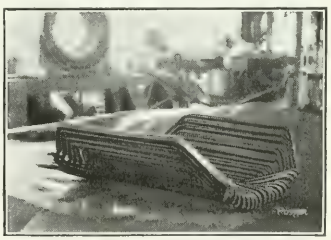


FIG. 21. A SHAPED GROUP OF COILS

The varnished cloth cell should be cut the same width as the fishpaper cell, but must be left long enough to guide the coil into the slot and protect it from injurious contact with the corners and

edges of the slot. Fig. 23 shows a stator with part of the cells in place and illustrates the method of inserting the cloth inner cells.

A cell-cutter similar to the one described in the article on rotor repairs should be used to cut the cells, and as the treated cloth is quite expensive, it will pay to devote a little time to finding out how to cut the cells with the least waste of material.

Inserting the Coils

The leatheroid cells should be placed

Fig. 22. Vise Attachments

in the slots before the insertion of the winding is started, but the cloth cells may be inserted one at a time, as the coils are put in. Both the cell and the coil should be dipped in powdered soapstone and the cell doubled around the part of the coil which is to go in the bottom of the slot. The upper halves of the first few coils,

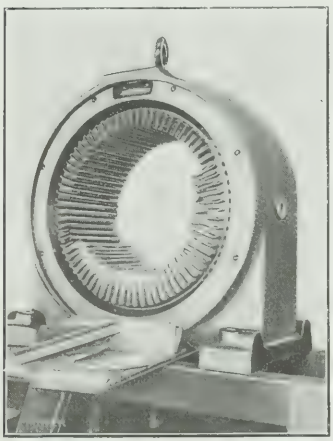


Fig. 23. Slot Troughs in Place

equalling the pitch or number, may be left out of the slots until the completion of the winding, as the lower halves of the last coils must lie beneath them. These coils are called the throw coils, and after they are in place all the following coil sides may be permanently inserted in the tops of the slots.

The lower half of each coil will force the treated cloth cell to the bottom of the slot, and will prevent the cell from doubling up under the coil as it would be apt to do if inserted before the coil.' Before inserting the top halves of the coils, an insulating separating strip of heavy treated cloth or leatheroid must be placed on top of the coil in the bottom of the slot. The projecting ends of the cloth cells must be held taut while the upper half of the coils is being inserted, or the cells will be pulled down and doubled up under the coils. When using right and left coils, great care must be used that the proper number of right and left coils are used for alternate groups.

Testing the Winding

When the entire winding is in place, the coil terminals must all be cut off to a uniform length, and all the coils of each phase should be temporarily connected together with No. 22 bare annealed copper wire. The series of tests for grounds, crossed phases, etc., described in the article on location of trouble must then be made and any defective coils displaced before proceeding any further.

Securing the Coils in Place

After the tests are all made, the cloth cells should be cut off close enough to the core to allow the ends to be lapped over inside the slots and under the retaining wedges. If the coils do not fill the slots to a sufficient height to be firmly held in place by the wedges, a layer of leatheroid must be used to fill up the

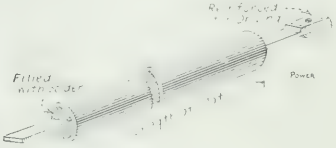


Fig. 24. Wedge-driving Tool

space. If new wedges are required, they must be made of the same dimensions and out of similar material to the original wedges. It is quite a difficult job to drive a long wedge without breaking it into pieces, and the tool shown in Fig. 24 will greatly facilitate this work. A piece of steel is cut slightly larger than one of the wedges and coated with a heavy oil. A piece of brass tubing a little longer than the wedge and large enough to admit the steel strip is procured, and the space between the strip and tube filled with solder. The solder will not adhere to the oiled strip, which may be withdrawn, leaving a slot large enough to admit the wedge. If the wedge is inserted in this tool and placed against one of the stator slots, it may be driven into place with the steel strip and a light hammer, without being bent or sprung.

If lacing rings are used, they must be of such diameter that the completed ring, with all the insulation in place, will be of an inside diameter about $\frac{3}{32}$ in. larger than the diameter of the circle made by the coils. If the ring is too large, it will double up when drawn up to the coils, and if too small, it will prevent the coils from resting on the bottoms of the slots.

If the ring is intended merely as an additional support for the end connections, its exact size is not so important, as the coils are held by the wedges, but if no wedges are used, the coils are liable to work outward and come in contact with the rotor unless properly secured.

Two men are required to lace a set of coils that are not held with wedges, one to pull the lacing taut and the other to drive the coil being laced to the bottom of the slot. The lacing should consist of three strands of ordinary wrapping twine in parallel, a needle made of soft copper wire being used to thread the lacing be-

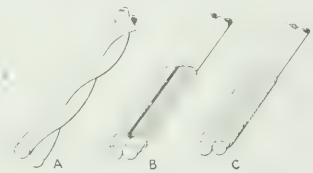


Fig. 25. Methods of Connection

tween the coils. The lacing rings should be given two wrappings of varnished cambric tape followed by a finishing layer of white linen tape and then well shellacked.

Connecting Up the Coils

The connections between coils must be made in the same manner as those of the original coils, a record of which should have been made before the old winding was disturbed. If for any reason this information is not available, the full-load current and speed of the motor given on the nameplate will aid in its determination. The number of poles per phase will be equal to 120 times the frequency in cycles per second, divided by the synchro-

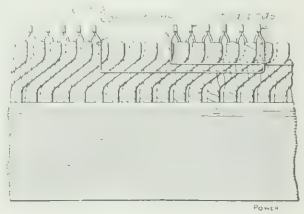


Fig. 26. Cross Connections

nous speed of the motor. If the synchronous speed is not given, adding about 6 per cent. to the full-load speed will give it In order to determine whether series or parallel grouping of the poles is correct, find the number of circular mils in the wire, and divide this by the full-load current of the motor. If the figure obtained is below 400, the poles must be paralleled (see also table of winding data).

If the terminals of the coils have been properly brought out, the beginning and ending of adjacent coils will lie close together and may be neatly bent into pairs and soldered. Fig. 25 shows three

methods of making the connections between coils. The method shown at *A* should never be used, as the connections are sure to break off the first time it is necessary to untwist the joint for testing. Method *B* is the best and consists of applying tinned copper sleeves which may be readily removed and can be used several times. Method *C* is a good substitute for rush work and small coils, but the connectors can be used but once.

The cross-connections between groups are made of magnet wire with several layers of tape well shellacked in place. When two-element coils are parallel-connected, the cross-connections must be made of magnet wire three sizes larger than that used in winding the coils or else two parallel wires used, if only one size is available. The cross-connections must be cut to length and bent down parallel to the coil terminals so that the stub ends will all be uniform in appearance. In order to facilitate testing, enough slack should be left in the cross-connections to allow them to be raised clear of the winding. This slack may be bent back out of the way, as shown in Fig. 26, and the entire winding given a finishing coat of varnish, after which the motor will be ready for service.

The accompanying table gives rewinding data for several sizes of Westinghouse "Type C" motors, which will serve as a guide in recovering lost connection data.

REWINDING DATA FOR TYPE "C," TWO-PHASE, 60-CYCLE INDUCTION MOTORS

Horsepower	Full Load Speed	Voltage	No. Coils	Elements per Coil	Turns per Element	Elements Connected	Turns per Coil	Coils per Group	Size of Wire B. & S.	Full Load Current	Circular Mils per Ampere	Pole Groups Connected	Remarks
2	1700	110	72	2	8	Par	8	9	19	104	500	Par	Groups 2 in ser., 2 in par.
2	1700	220	72	2	8	Par	8	9	19	52	500	Ser	
2	1700	220	72	2	8	Ser	16	9	19	52	500	Par	Groups 2 in ser., 2 in par.
2	1700	440	72	2	8	Ser	16	9	19	26	500	Ser	
5	1120	110	72	2	7	Par	7	6	14	26	630	Par	Groups 3 in ser., 2 in par.
5	1120	220	72	2	7	Par	7	6	14	13	630	Ser	
5	1120	220	72	2	7	Ser	14	6	14	13	630	Par	Groups 3 in ser., 2 in par.
5	1120	440	72	2	7	Ser	14	6	14	6.5	630	Ser	
10	850	110	96	2	7	Par	7	6	14	52	630	Par	Groups 2 in ser., 4 in par.
10	850	220	96	2	7	Par	7	6	11	26	630	Par	Groups 4 in ser., 2 in par.
10	850	440	96	2	7	Par	7	6	14	13	630	Ser	
10	850	880	96	2	7	Ser	14	6	14	6.5	630	Ser	
10	1120	110	72	2	4	Par	4	6	12	52	500	Par	Groups 3 in ser., 2 in par.
10	1120	220	72	2	4	Par	4	6	12	26	500	Ser	
10	1120	220	72	2	4	Ser	8	6	12	26	500	Par	Groups 3 in ser., 2 in par.
10	1120	440	72	2	4	Ser	8	6	12	13	500	Ser	
20	1120	110	72	2	4	Par	4	6	9	96	540	Par	Groups 3 in ser., 2 in par.
20	1120	220	72	2	4	Par	4	6	9	48	540	Ser	
20	1120	220	72	2	4	Ser	8	6	9	48	540	Par	Groups 3 in ser., 2 in par.
20	1120	440	72	2	4	Ser.	8	6	9	24	540	Ser	
50	850	110	96	2	3	Par.	3	6	9	220	475	Par.	Group 2 in ser., 4 in par.s
50	850	220	96	2	3	Par.	3	6	9	110	475	Par.	Groups 4 in ser., 2 in par.
50	850	440	96	2	3	Par.	3	6	9	55	475	Ser.	
50	850	880	96	2	3	Ser.	6	6	9	28	475	Ser.	

From a long series of experiments upon the transmission of heat through and from painted surfaces made by Prof. C. L. Norton some years ago, it was decided that the color of the pipe has little or no effect upon the radiation of heat. This view, so generally believed, has doubtless been confused with respect to the condition of the surface as regards glossiness or dullness. A dull surface has a radiation power of 120, while a glossy surface has about 101.

LETTERS

Perpetual Motion Again

A few days ago a perpetual-motion "crank" came into my engine room and began to talk perpetual motion to me. I told him that perpetual motion was against the laws of mechanics and he said he knew it but was going to try it any way. What he proposes to do is to set up a dynamo, a motor and a gasoline engine, each of the same horsepower, and connect the dynamo and motor shafts together, like a motor-generator set, with the addition of a clutch pulley for belt drive from the gasoline engine. He proposes to start the motor-generator set by means of the engine, to get the dynamo to generating; then turn the current from the dynamo into the motor, throw out the clutch that was used in getting the machine started, and let the thing run until it is worn entirely out! According to his idea, the dynamo will supply the current to drive the motor which will in turn drive the dynamo; simple, isn't it?

What is still worse, he thinks he will get excess current from the dynamo with which he can light up the town and drive all the machinery.

H. B. Adcock.

Newman, Ga.

[This fallacy has been explained away a good many times during the past thirty years. The arrangement would not continue running, after the clutch was pulled out, longer than the brief period necessary for the friction of the bearings and brushes to exhaust the momentum of the armatures. Because of the mechanical friction of bearings and brushes and the losses within the cores and windings of the two machines, the motor could not deliver to the dynamo as much power mechanically as it received from the dynamo electrically and the dynamo could not deliver to the motor as much electrical power as it received from the motor in mechanical power. This double shortage, of course, would prevent the machine from even driving its own shaft, to say nothing of delivering current for lights and motors.—Editor.]

Thawing Frozen Water Pipes

A couple of winters ago, I had about 150 ft. of ¾-in. pipe to thaw out and the only current available was that of a railway system supplied from rotary converters at 650 volts. The substation was 14 miles from the main power house, but by shutting down the converters and taking a time when everything was off the line we got about 500 volts. After rigging up a barrel as a water rheostat I attached one lead to a faucet at the extreme end of the ¾-in. pipe line and the other to a valve on the water main and lowered the upper terminal into the barrel until the ammeter showed 200 amperes; the voltage dropped to about 200. It took about 1½ hours to thaw out the pipe.

At another time the supply pipe to my house froze up; it was about 50 ft. long and ¾-in. pipe. I had a one-wire feed to the house from the trolley circuit and burned five lamps in series, grounding the return on the water pipe in the house.

I do not know how the current got back to the station; the water mains were all of wood. The trolley voltage was 650, but with the five lamps burning I got only 600 volts, showing a drop of 50 volts. On the night my pipe froze up, I connected the feed wire directly to the faucet of the water pipe and left it on all night, leaving the faucet partly open.

When I got up in the morning the water was running. I do not know how much current it took, but it could not have been very much because it was not enough to even warm up a No. 14 copper wire.

J. E. Bates.

Spokane, Wash.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

The Single Pipe System of Heating

By William Kavanagh

With the single-pipe system of heating only one pipe to each radiator is necessary for the satisfactory circulation of steam. For buildings up to 12 stories in height it will be found that 1¼-in. radiator pipe will give good results, and the diameter of the risers varies as a rule from 2½ to 3 in. In high buildings the risers will range in diameter from 3 to 5 in., while the radiators are usually tapped for 1½- or 2-in. pipe.

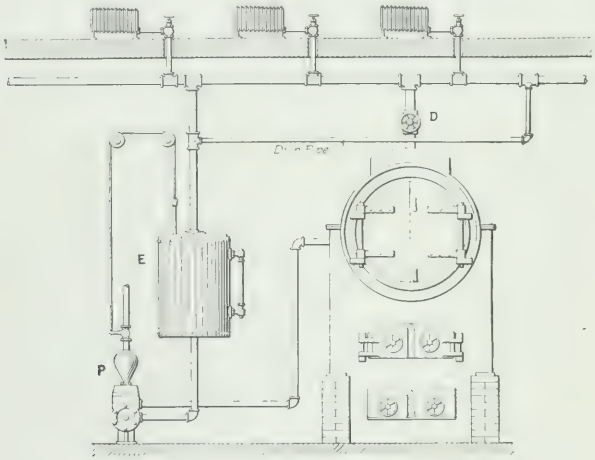


Fig. 1. Layout of a Single-pipe System

With the single-pipe system as now installed, the returned condensation is discharged into a tank that is usually situated at a height corresponding to the water level of the boilers so that the hot water will flow by gravity to the boiler-feed pump. Of course, this method is advantageous, but it will be shown that the use of the tank and pump is not at all necessary in returning the water of condensation to the boilers.

At first sight it would appear that circulation of steam cannot be attained with the single-pipe system, but on further consideration it will be found that the circulation is almost perfect. This is especially true when the radiators are properly erected and fitted with automatic air valves. The circulation of steam through the entire system is facilitated when the termination of each riser is extended and fitted with an air valve. The radiators are so constructed as to have the end at which the steam enters ¼ in. lower than the other. The incline given to each radiator makes it possible for the water of condensation to flow back by gravity toward the boiler.

If a receiving tank is used, it must be fitted with a gage-glass to show the water level, and a float is placed in the tank to control the steam or electric pump which discharges the water of condensation into the boilers. Such a system is shown in Fig. 1. The steam varying in pressure from that of the atmosphere upward passes out to the different risers through the main *D*, the condensation being returned to the tank *E*, equipped with float control. The tank *E* and pump *P* can be dispensed with if the drips are all connected to a common return which may be connected to the blowoff or the lowest part of the boiler.

In raising steam for this system, all valves should first be opened so as to avoid snapping and cracking in the pipes and radiators. The entire heating system will then become a part of the boiler and a noiseless circulation will result. If, however, steam is first raised and then allowed to flow through the piping, there will be plenty of noise.

One method of running the risers and attaching the radiators is shown in Fig. 2, and Fig. 3 shows another method which is excellent, as it allows each riser to be independently dripped and piped back to the tank or return pipe, thus insuring complete drainage of the system.

Fig. 4 shows how radiators may be connected to the riser when it is located in a corner, and Fig. 5 illustrates a method of connection when more than one radiator is required on the same pipe. The riser is shown at *R*. A Y-fitting is connected in the "run," as shown at *P*, to admit steam to the second radiator, which should be slightly elevated and pitched toward the riser. Fig. 6 shows another method of connection, and Fig. 7 shows a radiator attached to a riser terminating on the highest floor. The riser extends above the radiator and has a valve at *A*

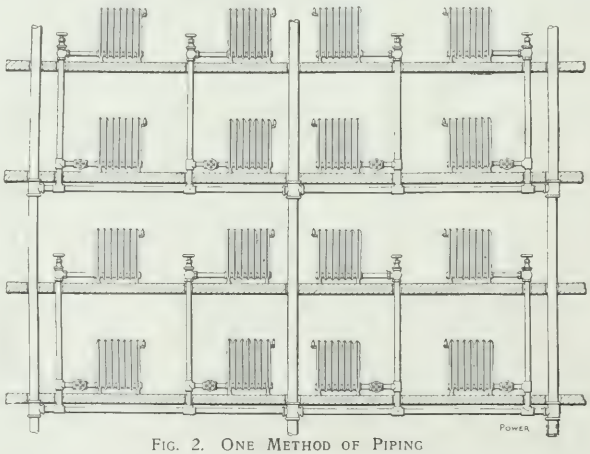


Fig. 2. One Method of Piping

to relieve the system of air and improve the circulation. In some buildings, the extended leg of the riser reaches almost to the ceiling.

An important addition to the single-pipe system of heating is to have the radiators connected to an air line leading to a vacuum pump. This facilitates the removal of the entrapped air, improves the circulation and permits a lower steam pressure on the boilers. With the air line installed, a steam pressure varying from 1 to 3 lb. will produce an excellent circulation throughout the entire system. In a certain 14-story building, good circulation is obtained in the radiators on the highest floor when the gage registers ½ lb. pressure, and during the coldest weather the pressure does not exceed 3 lb.

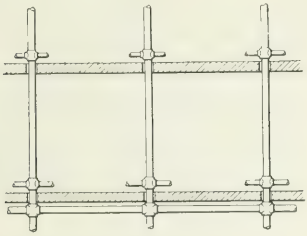


Fig. 3

for about three-fourths of the depth. If it is good practice to have the cold water discharged into the lower part of the tank, why not do it in the best and easiest way by making the connection at the lowest possible point; that is, directly into the bottom head, or through a cross one branch of which leads to the heater and the other to the draw-off valve?

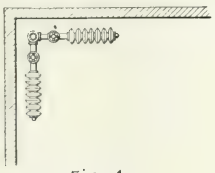


Fig. 4

Fig. 5

Surely no one will claim any advantage for the present method of jacketing the cold-water inlet pipe, and it has the disadvantages of taking heat from the surrounding hot water, so that the water drawn is continuously reduced in temperature.

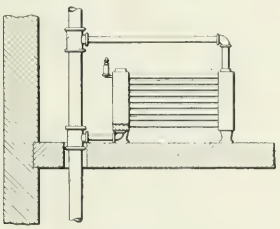


Fig. 6. Connection of Radiator to Riser

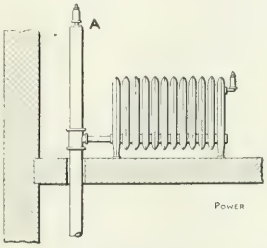


Fig. 7. Connection of Radiator on Top Floor

Where the cold-water inlet connection is made at the top of the tank, a continuation of the pipe down the inside of the tank is a necessity, as otherwise the cold water would shunt across to the hot-water outlet whenever water is drawn, but the amount of hot water which may be drawn is limited to the depth that the cold-water inlet pipe is submerged. If the cold-water connection is in the bottom head, the entire tank may be filled with hot water, instead of perhaps three-fourths of it, and all of this supply may be drawn off at practically constant temperature.

In regard to the hot-water return from the heater, it is certainly logical to say that if circulation is promoted by having this connection on the tank higher than the cold-water outlet from the tank to the heater, then instead of making this connection on the side of the tank at about half the depth, the best arrangement is to make it at the top; in fact, at the point now used for the cold-water inlet. Some may object to this arrangement on the ground that when hot water was drawn off the cold-water supply would not only enter the bottom of the tank but would force itself through the

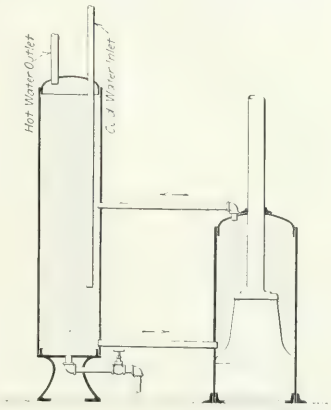


Fig. 1. Mr. Jones' Connections for Good Circulation

heater coil and discharge into the top of the tank on top of whatever hot water was still there. The fallacy in such an objection is that the cold water cannot rise any faster in the pipe leading out of the heater than it rises in the tank, while on account of the extra pipe friction, it will not actually rise quite as fast. This action will be readily apparent to everyone if it be imagined that as the hot water is drawn, some much heavier liquid, such as mercury, comes in through the cold-water connection.

Circulation is entirely a matter of difference in weight between equal volumes of hot and cold water. Starting with the system filled with cold water, if the hot-water return is on the side of the tank and only a single horizontal coil passes through the heater, there is for some time an uncertainty as to the water in direction of motion. Consequently, both hot and cold water are passing each other

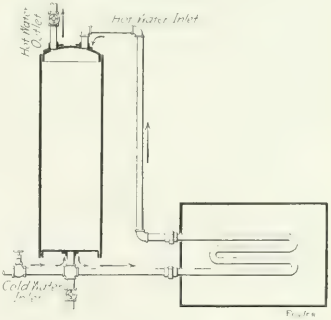


Fig. 2. A Better Arrangement

LETTERS

Piping a Water Heater

The illustration of "Proper Connections for Good Circulation" accompanying Mr. Jones' letter in the Jan. 2 issue does not agree with my idea of proper connections, even though it does represent a common practice. I object to the location of both the hot- and cold-water inlets as shown, and think I can point out a more logical arrangement.

In Mr. Jones' sketch, the cold-water connection is at the top, but the pipe is continued down the inside of the tank

in both connections between the tank and the heater. This results in overheating the coil in the heater, if it is in the firebox, and retards the circulation until there is an appreciable temperature difference in the water above and below the side opening. This defect is remedied by connecting the hot-water inlet to the top of the tank.

I do not object to Mr. Jones' sketch on the ground that such an arrangement will not furnish hot water, but I do maintain that the suggested arrangement will provide better circulation, a greater supply of hot water, a more uniform temperature and will be less expensive to install.

A. S. MERRILL.

Easton, Penn.

In the Jan. 2 issue, Mr. Jones shows his lack of practical experience with hot-water heating. I expect that the water can be used as heated if desired, as this is one reason why so many range boilers are being thus connected; there is hot water as soon as the heat strikes the circulating pipe and it is not necessary to wait until part of the reservoir is hot.

The manufacturers may put the cold-water inlet on top of the range boilers, but mainly because they have always done so, and it is easier for the plumber to make the connection. Of course, there are exceptions.

I can assure Mr. Jones that the saving effected was "not on paper" but in good paper money. Although the exhaust-pipe area was reduced, the heating coil acted as a condenser, and instead of causing a back pressure on the engine it would have a tendency to reduce the back pressure. The elbows and tees on the exhaust are outside of the question as they were in place at the beginning.

The vibration from the exhaust is taken up by the long upright pipes and affects the tank but little. There has been absolutely no water-hammer.

There is a gage on the exhaust pipe and it has never shown a back pressure greater since the coil was installed than it did before.

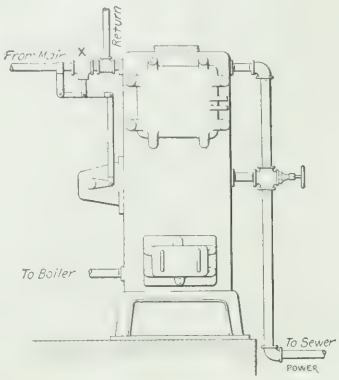
JAMES E. NOBLE.

Toronto, Can.

Leaky Valve Wastes Heat

The illustration shows one of the open types of exhaust heater used in connection with a vacuum system. The water bill was found to be high, and upon investigation the valve *X*, which is operated by a float on the interior of the heater, was found badly cut, and consequently it leaked considerably. The cold water from the city main was flowing into the heater and condensing the steam which should have been used to heat the building. The return water from the radiators was also wasted to the sewer.

The valve was repaired so that it would shut tight when the float was raised and the supply of exhaust steam was found to be sufficient to heat the building. The live-steam pipe to the radiator system was closed and less coal was burned as



CONNECTIONS TO HEATER

the feed water was going to the boiler at 160 deg. There are, no doubt, other cases of this kind.

C. R. MCGAHEY.

Baltimore, Md.

Radiator Troubles

How the steam connections were made to two radiators situated in a lobby outside of a dining room is shown in Fig. 1.

The steam piping ran underneath the lobby and was connected vertically to the radiator by two 1-in. pipes 4 ft. 6 in. long. It was about 15 ft. from the steam main to the first radiator and about 35 ft. to the second. The pipes were well lagged and on the return side of each

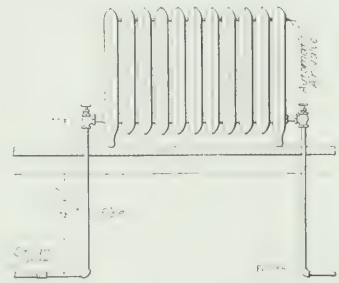


FIG. 1. ORIGINAL METHOD OF PIPING RADIATOR

radiator was a steam trap discharging to a drain.

The radiators were first coupled up as in Fig. 1, but they did not give satisfaction. Unless the valves were opened fully, the radiators would not get hot and when they were opened wide there was a good deal of water-hammer, which eventually split several segments. To remedy the trouble several experts were called, and the first expert put a check in the running thread, Fig. 1, in the steam-inlet pipe. This consisted of a lead disk with a small hole about $\frac{1}{16}$ in. in diameter, the idea being to prevent a

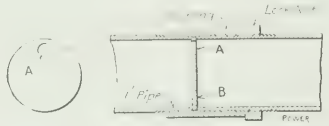


FIG. 2. THROTTLING STEAM SUPPLY

sudden rush of steam and water from getting into the radiator when the valve was opened fully. This plan did not answer very well.

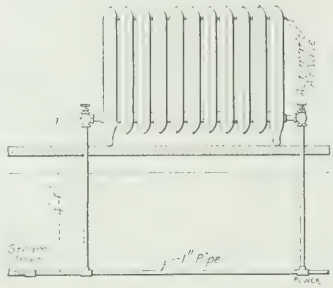


FIG. 3. SHUNT CONNECTION ADOPTED

Another firm was called in and on taking the check out of the steam pipe the $\frac{1}{16}$-in. hole was found to be at the top of the disk, shown at *A* in Fig. 2. This allowed the condensation to fill the pipe to the level of the hole *A*. It was intended, of course, to have the hole at the bottom of the pipe, as at *B*, so as to

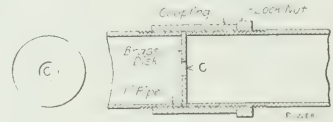


FIG. 4. THROTTLING DISK WITH HOLE IN CENTER

allow the condensation to run through as fast as formed.

The connections to the radiators were now altered and connected up as in Fig. 3. With the shunt connection shown, the condensation had a straight run to the trap and it was not necessary to pass it through the radiator as in Fig. 1.

A brass check was substituted for the lead one and a $\frac{1}{16}$-in. hole was made in the middle of the disk, so that at the worst the pipe could only fill up to about one-third its diameter before the water would flow through the hole in the check.

On opening the valves the radiator was found to warm up equally from both ends and got thoroughly hot. No more trouble was experienced from water-hammer.

O. G. A. PETTERSSON.

St. James, Manitoba, Can.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, sec'y.
505 Pearl Street, New York.
1225outh Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71 Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

Every copy of Jan. 16, 1912, issue has been sold—subscriptions taken after Jan. 16 will start with Feb. 6, 1912.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

A Few Factors in Economical Operation

No fixed rule can be given and no particular type of equipment recommended which will always insure maximum efficiency of operation in any and all power plants, but some of the factors in economical service which are working out well in a few stations recently visited may profitably be mentioned. Leading engineers are attacking the cost question from more than one angle, in the first place; that means a good deal in itself, for one gets more side lights on the behavior and possibilities of his equipment if he investigates its service along several different lines. For example, the problem of cutting down the losses occurring in stand-by periods requires one point of view, the more complete measurement of the raw material of power, so to speak, on the steam side of the house is another matter bearing upon costs in a different way; thirdly, as the old-fashioned country minister used to say when he had just got warmed up in his sermon, there is a great deal to be done along the line of carrying the load to advantage when several different sizes and types of prime movers are concerned.

One plant is getting some results from the use of supplementary dampers on individual boilers, so that the draft on every banked fire goes away down to the bottom of the gage when the service of the unit is not required. In this case each stand-by damper is set in the boiler uptake and the dampers of every battery are controlled by chains leading to adjusting hooks on a draft-control board at the side of the setting near the floor level. As this is a Western station located in a field where the cost of coal is prohibitive, it burns fuel oil, which means additional control of the heat units blown into the furnace through appropriate valves and bypass piping.

The owners of this station thought it a good investment to spend a few hundred dollars in steam and water meters, recording thermometers and curve-drawing instruments, which will show the chief engineer and his superiors, the assistant operators in the turbine room and the firemen as well, the conditions which existed at any hour of the twenty-four in the steam end of the plant, as regards all the important heat-carrying fluids and gases. It is not going to take two or three college professors and a score of willing but perhaps somewhat inexperienced student assistants to find out when this station departs from its normal economy by a percentage which calls for prompt action.

In another case the plant owner has put individual motor-driven fans in the boiler uptakes, each boiler having its own short stack. The motors are equipped with variable-field speed control, which is the real point of the situation, and they are designed to operate at diverse speeds within a range of three to one without falling off very far in efficiency. It is a different story here from that in the plant where fan speeds are regulated by varying dead resistance in series with an old railway motor. Again, improved conditions of operation have resulted from the concentration of all auxiliary electrical control equipment at a single section of the switchboard, including the relocation of the exciters at a point within a few feet of the switchboard operator. Space has been saved by the installation of compressed air piping in place of dead pipe railings in the gallery sections of the boiler room, and a recent extension of the latter has been greatly improved from the standpoint of supervision and replacement of stoker and furnace parts by a twenty-five per cent. increase in the width of the firing aisle.

The adoption of the now well known plan of passing the condensate from the lower tubes of the surface condenser through a heating section in close contact with the heat of the exhaust steam is a point which is receiving a good deal of favorable consideration in another locality, and in still another place the

cost of excavation to allow the condensing apparatus to be located far enough below a small canal to obtain circulating water by gravity was found well warranted.

The cost of power was cut twenty per cent. in six months in another station by simply taking greater care to handle the load on individual prime movers in such a way that no unit would for any length of time be run at much less than half load, three-quarter load being the more common rate. In this case the problem was complicated by the fact that alternating- and direct-current generating units were run side by side in the same building, the former feeding the same network as the latter, through rotary-converter substations in the suburbs. By watching the location of the load carefully it was possible to reduce the amount of idle running in the plant to a surprising extent.

A close supervision of the use of supplies and the strict limitation of working boiler pressures to values below the safety-valve settings produced notable gains in efficiency in several stations.

Six Year Engineering Course at Columbia

At the annual meeting of the trustees of Columbia University on Jan. 8, it was decided to extend the engineering courses to six years so as to include two years of regular academic work. Under this arrangement, after September, 1914, the engineering courses will be open only to those who have completed two years in the arts course in Columbia or some other college of recognized standing.

In view of the important standing now accorded engineers and the ever increasing scope of their activities, it is essential that their training include something more than merely technical knowledge; in other words, their education must be broad. As a means toward this end, the recent action of the Columbia trustees is commendable. However, we question whether a compulsory six-year course will not deter many (for financial or other equally strong reasons) from entering upon an engineering career. Might it not have been better to have left the four-year course as optional, at the same time recommending the six-year course to all those who are in a position to take it? This practice has already been followed by several other universities.

Steam Pipe Supports

The constant movement of a steam line due to expansion and contraction necessitates the use of supports that will offer the least resistance to this movement so that no undue stress will be transmitted to the various connections.

The variations in the length of a steam line depend upon the initial length of the line and the difference in temperatures between that at which the line was put up and that of the steam passing through. In a very long line, or where superheated steam is used, these variations are considerable and must be provided for by designing and arranging the supports so as not to prevent the free movement necessary to relieve the expansion stresses, except, of course, at such points as are intentionally selected as an anchorage. There is also a lateral movement of the line due to the push of the branch pipes for which care must be taken.

There are a number of different kinds of pipe supports in use that meet all the requirements and a proper selection can only be governed by local conditions. For example, there are hangers from above supported from the bottom cords of the roof trusses; brackets on which the pipe directly rests; steel pillars or posts of sufficient slenderness to allow free movement, which are sometimes convenient for carrying the pipes from the crown of the boilers or from the brick settings; rollers carried by brackets and other devices.

The most common form of support is, perhaps, the hanger in which the pipe is suspended. This type gives free movement to the pipe but lacks a sufficient stability; consequently, the line will often be set to swinging or vibrating by the pulsations due to the draft of steam from the engines. This may usually be checked by lightly wedging the pipe at some point where the branch passes through a wall or near a column or other fixed object. When the pipe is simply supported on brackets it will not vibrate so readily.

Brackets are often hollowed out to suit the contour of the pipe, but this is a rather doubtful advantage as they tend to prevent all lateral movement and thus cause a strain on the branches as well as on the bracket supports and fastenings. It is better to have the top or table of the bracket flat so that the pipe will be free to move both ways. To prevent undue wear on the outside of the pipe, small wearing strips are often inserted between the surfaces of the pipe and the bracket with excellent results. These strips should be from about $\frac{3}{8}$ to $\frac{5}{8}$ in. thick and can easily be held in place by means of light rings encircling the pipe. They should, of course, move with the pipe and not be fastened to the bracket; otherwise they would lose entirely the purpose for which they are intended.

The use of rollers for carrying pipes is usually not so good an arrangement as the plain bracket where a rubbing contact is introduced because of the latter's greater tendency toward stability. A pipe line resting on rollers is, however, less liable to vibrate than one suspended in hangers. Perhaps the greatest objection to the roller is that it is liable to become fast and consequently wear the pipe, a condition which naturally would not be looked for with this type of support and, therefore, might not be noticed until some damage had resulted.

One good operating kink is many times invaluable to a hundred engineers, but occasionally a contributor, for fear of aiming too wide of the mark, will spend hours of his time for relaxation in dilating upon his subject when a few simple words to the point will tell the story. Brevity is as much the soul of writing for your paper as it is of wit.

Of the thousands of steam boilers installed in the basements of buildings and under sidewalks, few are removed. Many of them are old but are allowed to carry pressures ranging between 80 and 90 lb. per square inch. Something serious will happen one of these days.

Every operating engineer who is interested in the work being done throughout the United States in vocational training should read of it in the twenty-fifth annual report of the commissioner of labor at Washington. It may be had on application.

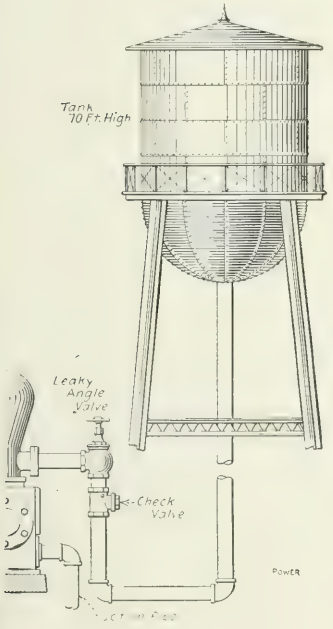
No trouble at all in getting data regarding boiler accidents from the new board of boiler inspectors of New York City. It is a good beginning and most gratifying.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Vertical Check Valve Did Not Work

Some few days ago the writer was called out on a trouble job in a small light and water plant the engineer of which said that something was the matter with the check valve in the sprinkler-tank line and that it had never worked at all. He had taken the cap off several times, but he could not locate the trouble. The tank on the tower was kept full of water all the time on account of fire insurance. The tank was filled every night, but in the morning all the water was back in the reservoir again because the angle valve and check valve shown in the accompanying figure leaked, the water going back through the pump valves.



SHOWING LOCATION OF THE CHECK VALVE

The trouble was that the check would stay open all of the time because the pressure was balanced between the pump and the tank, and the check sank to the bottom. If there had been a strong back flow the check might have worked. I fixed it by placing a spring under it to make it stay up to its seat. It is easy to see that the check ought to have been placed in the horizontal line.

H. T. FRYANT.

Columbus, Miss.

Blow Hole Caused Crack in Shaft

While employed as master mechanic in one of the steel mills in Austria I had a most interesting experience. On a certain morning one of the engineers came to my office and asked me to go with him to the bessemer plant and examine the 1200-hp. blowing engine. As something seemed to be wrong with one of the main bearings, I put my hand on the shaft close to the bearing face, as at *C*, Fig. 1, and found that apparently minute babbitt filings were running out with the oil. It is putting it mildly to say that my curiosity was aroused, and I decided to wait until after the heat was finished so that the engine could be stopped and the shaft examined.

Fig. 1 Showing Blowhole and Crack

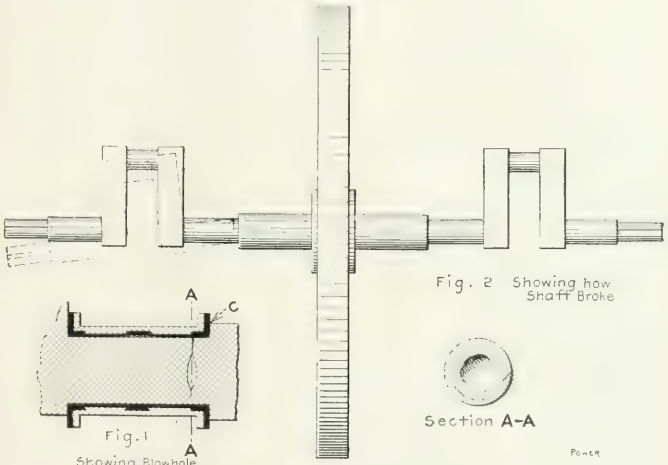


Fig. 2 Showing how Shaft Broke

Section A-A

POWER

Stopping the engine meant shutting down the converter plant as we had no spare unit. We were lucky that we did not let any objections on the part of the foreman prevent us from shutting down, as later events proved.

When the engine was stopped the cap of the bearing was taken off and the shaft examined. About 5/8 in. from the face of the bearing we discovered a very fine zigzag crack which extended over about half of the circumference of the shaft, which was 14 in. in diameter. The circumstance seemed serious enough to warrant a more thorough investigation before the engine was again put into service, and we decided to lift the shaft out of the bearings for the purpose of a more complete inspection.

The shaft had been raised about 8 in. clear of the bearings when it broke with a loud crash, falling into the bearings and breaking them. Of course, the break in the shaft had occurred where the crack had been. We examined the faces of the break and found that the shaft contained a blow-hole at that point, about 8 in. in diameter and 3 in. thick, which had not come out even when the shaft had been forged—a most remarkable fact. When the break occurred about one-tenth of the full area of the shaft still remained intact; the rest of the fracture showed a rather smooth surface and no doubt it had been developing for the past six years, during which time the engine had been in constant use.

In view of the comparatively slight damage that was done we felt that we had escaped very luckily; had the shaft broken while the engine was in full operation the results would have been disastrous indeed.

ALOIS HAUSER.

South Chicago, Ill.

Oil Tray Stand

Having seen in POWER an illustration f a stand for oil cans, I am lead to de-cribe the one I made and am using.

It is made principally of 1x⅛-in. gal-anized strips. The top of the table, 13

HOME-MADE OIL-TRAY STAND

in. in diameter, is made of wood held inside the band.

I have a nickel-plated tray on which to set my cans. The whole presents a good appearance and cost for material, aside from the tray, just 20 cents

F. W. BAIR.

Hancock, Mich.

Dynamite for Removing Pinion from Shaft

The machinists in the plant where I am employed pulled off a stunt recently, a description of which may help someone out of a tight place some time.

We were all to have a half holiday to attend the county fair and on this particular day at about 10:30 a.m., the 3-inch drive shaft on a mill broke off close in the end of the driving pinion. The pinion was about 10 inches in diameter by 14 inches long and had 15 teeth. The mill was needed badly the next morning.

The first step was to get a new shaft, which was an easy one, as the manufacturers of the mill have a local storehouse for repairs and we had only to send the teamster a few blocks to get it.

The second problem was to get the pinion off of the old shaft and onto the new one, and as it had taken about six hours of hard sledging and drilling, to get this same pinion off once before when the shaft broke, it looked as if someone was doomed to miss the fair.

All efforts to drive out the old shaft did not seem to have any appreciable effect. Someone suggested dynamite, and they grabbed at the suggestion like a drowning man grabs at a straw.

The pinion was laid on its side at a safe distance from all buildings, one stick of dynamite was set against the end of the shaft where it was broken off and then mudded in with stiff clay. When everyone got under cover the dynamite was exploded. The concussion loosened things up so that five minutes' work removed the shaft, and everyone went to the fair.

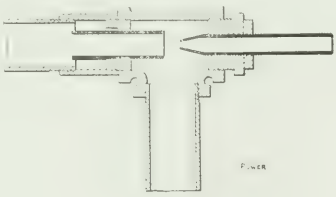
EARL PAGETT.

Coffeyville, Kan.

Home Made Ejector

The figure shown herewith illustrates the construction of a steam siphon or ejector that can be easily and cheaply made with a few common pipe fittings.

I have made five of these lately, and two of them have been in service 24 hours per day for the past few months. All are of the 3-in. size, the suction pipe is 3 in. while the outlet or discharge is sometimes reduced to 2½ in. The list of fittings needed is as follows: One 3-in. tee, one 3x1½-in. face bushing, one 3x1-in. bushing, one 3-in. pipe coupling, one 1-in. locknut (when the locknut was not at hand I sawed a piece off a 1-in. coupling and used it as a locknut.), one 1½-in. nipple 6 in. long with a thread on one end long enough to permit it to be screwed through the face bushing to the center of the tee; omitting the thread on other end; one 1-in. nipple drawn to a point and a ⅜-in. hole drilled into the small end.



SECTION SHOWING DESIGN OF EJECTOR

This forms the steam nozzle and is screwed into the tee through the 3x1-in. bushing to within 1¾ in. from the 1½-in. nipple which forms the delivery nozzle. The 1-in. nipple has a long thread cut on the nozzle end to permit the adjustment of the nozzle as the siphon will not work unless it is properly adjusted. This can be done only by trying it, and when the nozzle is in the right place, the locknut is run up tight against the 3x1-in. bushing.

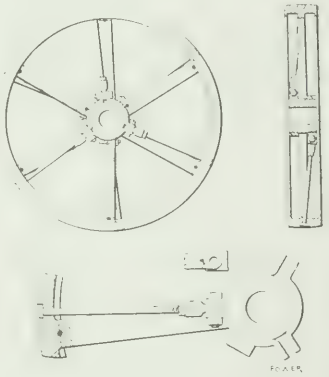
The place where the nozzle works best is generally about 1¾ in. from the 1½-in. nipple, which forms the delivery nozzle. The 1½-in. nipple is screwed through the face bushing to the center of the tee. The face bushing is screwed about half of its threads into the tee and the 3-in. pipe coupling is screwed on the other half of the threads. All similar siphons I have made work on 12- and 15-ft. lifts throwing 2½-in. streams of water.

ROMAN S. WILHELM.

Indianapolis, Ind.

Flywheel Repair

The engine carrying this wheel was equipped with a ball governor having no automatic stop. The governor belt broke and permitted the engine to run away and break the wheel.



SHOWING MANNER OF REPAIRING FLYWHEEL

Five of the six spokes broke at the rim and at the hub, but the remaining spoke broke at the rim only.

The accompanying figure illustrates the manner in which the wheel was repaired.

This wheel was repaired six months ago and has been giving satisfaction ever since. When it is taken into consideration that this engine runs almost 24 hours a day, it is reasonable to assume that the repair will last as long as the engine.

The ⅞-in. studs shown in the cracks were put in and riveted to prevent the arms from "walking" out of position.

JOSEPH F. PFLUM.

Canton, Ill.

How to Test and Treat Feed Water

I think it is generally conceded by engineers that the weak place in a modern steam plant is the boiler equipment. There have been wonderful improvements in engines and electrical machinery in the last few years, but little has been done to make life easier for the boiler-room force.

In my own experience, the principal trouble is with scale and corrosion. I have tried numberless kinds of boiler

compounds, and at first got excellent results from all of them. But invariably disappointment came, due, I suppose, to the continual changing of the composition of the water at different seasons of the year.

We have water here containing at different seasons from 30 to 50 grains of solids to the gallon; these are of such a nature that I have screwed on a 2-in. pipe fitting by hand, and in two months I have been unable to take the fitting off without splitting it.

Some years ago I started to study up on water softeners, believing that my best course lay in softening the water before it went to the boiler. I wrote to an engineering magazine for advice, and in reply received a letter advising me by no means to undertake anything of the sort, as I would get into all kinds of trouble. It ended by giving me the name of a firm making water-softening apparatus. I wrote to this firm, and in reply got a proposition that would have meant an expense of over $2000 if I had taken it up. As the entire boiler plant to be protected by this apparatus cost less than this amount, it can easily be guessed that I did not pursue the matter much further.

I have kept a close watch on the trade papers, and have seen a good many articles by college professors, etc., on the subject, but invariably they have been too heavy for engineers who, like me, are shy on technical education, or who have no time to wade through it all to get the application for their own needs.

I have studied and experimented and talked to everybody I met who knew anything about the subject, until I can now keep my boilers absolutely clean with about two hours' work per month.

I use lime and soda only, but it is important to get the right proportions of each, and this is easily done.

The apparatus and chemicals needed are, one burette graduated in $\frac{1}{10}$ c.c., one 50-c.c. graduate cylinder, 2 oz. of phenolphthalein in solution, 2 oz. of methyl orange, and 4 oz. of $\frac{1}{10}$ normal sulphuric acid. These chemicals can be obtained of any chemist, and they will be sufficient for a year or more.

In testing the treated water, it is necessary to find the degree of alkalinity and of causticity. First secure an analysis of the raw water, and for each grain per gallon of carbonate of lime, as shown by such analysis, put into each 1000 gal of water to be treated 0.098 lb. of common unslacked lime. To each grain per gallon of carbonate of magnesia add 0.234 lb. of lime; for each grain per gallon of sulphate of lime add 0.125 lb. soda ash; for each grain per gallon of sulphate of magnesia add 0.08 lb. of lime and 0.14 lb. of soda; for each grain per gallon of chloride of magnesia add 0.1 lb. of lime and 0.17 lb. of soda.

To provide for the constant changes in the water, it will be necessary to test the treated water occasionally, which is done as follows: Measure accurately 50 c.c. of the treated water and pour it into a clear-glass tumbler. Add with a medicine dropper 2 drops of the methyl orange and a few drops of the phenol. Shake until thoroughly mixed. Then fill the burette with the sulphuric acid and run it into the tumbler, drop by drop, until the red color in the water just changes to yellow. Take the reading of the burette before and after, the difference between the two readings being the amount of acid necessary to make this change. Each $\frac{1}{10}$ c.c. indicates 1 part per 100,000 of causticity.

Now run in more of the sulphuric acid until the yellow color just changes to pink; each $\frac{1}{10}$ c.c. of acid used indicates 1 part per 100,000 of alkalinity. The alkalinity includes the causticity, and is therefore always the greater. In practice, the causticity should be about half the alkalinity.

If the test shows less than half, more lime should be added; that is, there should be more in proportion to the soda used. I slake up at one time enough lime and soda to last several days, and put enough of the mixture into my settling tanks so that the water in the boiler begins to show just a little discoloration in the gage-glass. If too much is used it might cause priming, but a little care at first will soon show the proper amount to use. The really important thing is to change the proportions of lime and soda to suit the changes in the raw water. I use two wooden tanks for settling the water, each large enough to hold water for six or eight hours' run, using them alternately.

I believe that any engineer can rig up such an outfit at small expense, and that by using a little judgment in following out these directions he can, in the main, get results that will surprise him. I will be glad to hear from anyone trying the plan, and will answer any questions put to me by anyone wanting further information.

ALBERT J. WICKES.

San Luis Obispo, Calif.

Isolated Plant Engineers' Opportunities

In view of the continuous encroachment of the central station, it is up to the isolated-plant engineer to put on his thinking cap, and find out for himself in what way he can increase the efficiency and the economy of the machinery in his care.

It is safe to say that not a single plant is running where some economy could not be effected, some improvement made involving greater efficiency, if the engineer would but take the time and trouble, apart from his ordinary duties, to look closely into all the details of his plant.

How often one sees large quantities of wasted coal and gases pouring out of the stack in the form of smoke. The only effective "smoke preventer" is a good fireman.

In very many small plants, exhaust steam goes direct into the atmosphere and is lost, when useful work might easily be obtained from it for heating the boiler-feed water, etc. The advantages of heating the feed consist not only in a direct saving of fuel but also in a reduction in the strains in the boiler, tending to prolong its life, and minimizing the danger of leakage and consequent deterioration, which is often very rapid. A little ingenuity on the part of the engineer, and the exhaust steam from noncondensing engines could be made to effect a considerable saving in the coal account.

Another way in which to effect a saving is to place a series of pipes in the flue between the boiler and the stack and pass the feed water through these pipes. The percentage of saving effected in heating the feed water by such an economizer, or by an exhaust-steam feed-water heater, is found as follows:

$$100 \times \left(\frac{T}{H} - \frac{t}{t}\right) \quad \textit{percentage of saving}$$

where

T = Final temperature of the feed water;

t = Temperature of feed water before heating;

H = Total heat of the steam in the boiler at any pressure above the atmosphere.

With gases leaving the boiler at a temperature of 650 to 700 degrees Fahrenheit the temperature of the feed water from the hotwell may be raised in such an economizer as high as 300 degrees Fahrenheit and even higher, resulting in a very decided economy. It is not desirable to put in an economizer when the temperature of the gases on leaving the boiler is below 400 degrees Fahrenheit.

To further insure economy in the use of the steam and the efficient operation of the engine generally, the intelligent application of the steam-engine indicator is not only necessary but imperative. The indicator diagram affords an excellent guide in setting the valves of the engine; it enables the horsepower developed to be readily calculated, and it generally reveals the whole behavior of the steam during the performance of its work in the steam-engine cylinder.

If the operating engineer would in every case rise to his opportunities, there would be little danger (except in some extreme cases) of his being supplanted by the use of power from the central station.

JOHN CREEN.

Seattle, Wash.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Inertia of Air Compressor Intake

Some time ago, Snowden B. Redfield wrote an interesting article in POWER concerning the gain in the volumetric efficiency of an air compressor, made possible by utilizing the inertia of the moving column of air in a long intake to partially compress the air in the cylinder at the end of the suction stroke. In a more recent issue, John S. Leese has added a few words on the same subject. That there is such an inertia effect and that under some conditions it has a tendency to increase the volumetric efficiency of the compressor I think no one will deny, but the gain is not so great as Mr. Redfield would lead one to believe.

To illustrate his views he calculates a specific example. His method is interesting and probably gives a fair approximation of what might be expected, but when he states that the results represent an increase in volumetric efficiency of 5 per cent., he takes into account only the pressure and the volume and overlooks the third important factor, temperature.

In the case under discussion, since no effort is made to cool the intake and since the number of compressions is so great, the compression will be very nearly adiabatic. If it is assumed that this is the case, then the rise in temperature can be calculated by the formula

$$T_2 = T_1 \left(\frac{p_2}{p_1}\right)^{0.29}$$

where T_1 and T_2 equal the absolute temperatures before and after compression and p_1 and p_2 the respective absolute pressures. Since an inlet temperature of 60 deg. F. was assumed the temperature of the air in the cylinder after it has been compressed to a gage pressure of 0.726 lb. per square inch by the inertia effect will be

$$T_2 = (460 + 60)\left(\frac{14.7 + 0.726}{14.7}\right)^{0.29} = 527.32 \text{ deg. } F.$$

above absolute zero or

$$527.32 - 460 = 67.32 \text{ deg. } F.$$

above Fahrenheit zero; that is, the inertia compression has warmed the air 7.32 deg. To find the effect this has on the volumetric efficiency the actual weight of the air under these conditions must be found.

To find the weight of air at any pressure and temperature this formula may be used:

$$w = \frac{pv}{53.35\,T}$$

where

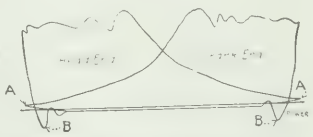
w = Weight in pounds;
p = Absolute pressure in pounds per square foot;
v = Volume in cubic feet;
T = Absolute temperature F. degrees.

Since the actual cylinder capacity of the compressor does not enter into this part of the problem, for the sake of simplicity, assume the piston displacement to be 1 cu.ft. Then applying the formula for air at 60 deg. temperature and atmospheric pressure,

$$w = \frac{14.7 \times 144 \times 1}{53.35 \times (460 + 60)} = 0.076303 \text{ lb. per cu.ft.}$$

For air at 67.32 deg. and gage pressure 0.726 lb. per square inch,

$$w = \frac{(14.7 + 0.726) \times 144 \times 1}{53.35 \times (460 + 67.32)} = 0.07896 \text{ lb. per cu.ft.}$$



REPRODUCTION OF DIAGRAMS IN FIG. 1 OF MR. REDFIELD'S ARTICLE, SHOWING EFFECT OF AIR INERTIA

The ratio of the volumetric efficiencies of the compressor when using the direct and when using the long intake will be approximately equal to the ratio of the weights of the air in the cylinder at the commencement of the compression stroke. Then, if a volumetric efficiency of 80 per cent. is assumed when the compressor is getting its air direct and calling the volumetric efficiency with the long intake equal to x,

$$\frac{80}{x} = \frac{0.076303}{0.078960}$$

or $x = 82.786$ per cent., thus showing a gain of 2.786 per cent. in favor of the long intake at the head end. At the crank end a similar calculation based on Mr. Redfield's figures shows a gain of 1.86 per cent., making the gain for both ends average about 2.3 per cent.

The question now arises, will an increase of 2.3 per cent. in the volumetric efficiency of the compressor show an appreciable decrease in the power required to drive it? Mr. Redfield admits that the momentum given to the air in the intake must have been obtained from the compressor piston, and this in turn must have received the necessary power from the driving mechanism.

If, then, the inertia effect is as efficient in compressing the air into the cylinder as the piston is in compressing it into the discharge, then as far as the actual air compressing is concerned, the power required per unit weight of air will be neither increased nor decreased by the addition of the long intake. But, since the volumetric efficiency has been increased 2.3 per cent., then to compress the same amount of air the compressor speed can be reduced in proportion, and would reduce the friction loss of the compressor. If the loss by mechanical friction in the compressor is 15 per cent., then a reduction in speed of 2.3 per cent. would save 2.3 per cent. of 15 per cent. = 0.345 per cent. of the total power required to drive the compressor.

This small gain is more than swallowed up by the friction losses in the intake. An examination of the indicator diagrams shown by Mr. Redfield as Fig. 1 will show that the area between the "hook" at B and the atmospheric line is much greater than the area under the toe at A bounded by the atmospheric line, the suction line, and a line drawn from the point A to the atmospheric line. This shows that the power required to get the column of air in the intake in motion is much greater than the power given up by its momentum at the end of the stroke.

The difference between these areas represents the air friction loss through the intake and the suction valves. The excessive drop in pressure at the beginning of the suction stroke shows that a rebound has taken place, and that at the instant of the opening of the valve the air has reversed its flow and is backing out of the intake. This rebound, or outward rushing of the air, can very often be distinctly felt at the outer end of the intake. It is this forward and backward swishing of the air, and the resulting loss through friction and temperature rise that cause the gain to be converted into a loss on the power end.

A. E. MUELLER.

Mayville, Wis.

Coal and Clinkers

I have read Mr. Bailey's article in the Nov. 28 issue and the one by him published some time ago, and, while both are interesting and instructive, I think he lays too much stress on the importance of the fusing point of the ash. It is a hard thing to lay down any rule for determining the clinkering properties of coal by any chemical analysis, as Mr. Bailey has pointed out, and it is logical that the lower the fusing point of the ash, the more clinker there will be formed. However, I claim that the clinkering properties of coal depend almost as much on the conditions under which it is burned as on the fusing point of the ash; that is, under certain conditions almost any coal will form considerable clinker, while under other conditions a coal containing very fusible ash can be burned without difficulty.

Just what makes ashes fusible depends on various constituents, no one of which can be used as a positive indication of fusibility. Certain proportions of lime and silica will fuse very easily, while other proportions of the same elements will make an almost infusible mixture. Anybody familiar with blast-furnace work knows that the chemists figure out the charges of limestone and ore, which contain silica, in order to get a slag of a certain fusibility.

Iron in the lower state of oxidation is a very powerful flux for silica. When iron in this condition comes in contact with the bridge-wall or side walls, it fluxes the firebrick, and forms a hard clinker which sticks to the walls and which it is almost impossible to break off. It must not be understood that a high percentage of iron in the ash is a positive proof of clinkering properties. Several persons, including Mr. Bailey, have shown that the relation of iron to clinker is not positive. If a laboratory is available and an analysis of the clinker can be made, the troublesome factor can be quickly determined.

The formation of clinker has been prevented by various methods; in some cases by mixing lime, limestone or oyster shells in the coal, and in others by adding sand, clay or similar materials, and in still others by mixing two kinds of coal. Again, the admission of steam under the grates or the presence of water in the ashpit has often given good results.

I do not consider the fusing temperature of the ash anything like as important in buying coal as the heat value. By that I mean the temperature as determined in the laboratory. Very few buyers will purchase a coal on specification only without a preliminary trial, and if a coal clinkers badly under trial I would say to reject it regardless of its ash-fusing temperature. As to the heat value, the heat is what coal is bought for, and it necessarily follows that this should be the basis of the selling price.

It is possible that a sample of the ash prepared in the laboratory would have a different fusing point than that which would be produced in the furnace. While in most cases I would consider this improbable, it is not impossible, and the matter would stand investigation.

Further, coals having ash of low fusing point might be such that their burning temperature would be correspondingly low. For example, lignitic coals often have fusible ash but do not often make clinkers as they burn at a low temperature. Conditions might be such that very little clinker would be formed in any case, as, for instance, with a small boiler with a light load, special settings, etc.

Nearly all tests seem to show that the efficiency does not fall to any marked degree unless the clinker is excessive, say, about 50 per cent. of the ash and refuse. However, as a rule, it is impossible to get a high capacity out of boilers when clinkering troubles are experienced. In plants where high peak loads have to be carried for certain periods, even a moderately clinkering coal would be fatal, but many plants which have a moderate, even load could handle the same coal very successfully. A practical test under the conditions required is the only way in which to find whether coal is suitable regardless of all the laboratory determinations. After the requirements have been met successfully the basis of price should be the amount of heat available for steam-making purposes.

James E. Steely.

Covington, Va.

Broken Valve Crosshead

After reading over the letter of R. A. Cultra, in the Dec. 19 number, I think that I may be able to help him a little.

I am operating a Green engine built about 18 years ago by the Providence Engine Works, Providence, R. I. This engine is a little larger than Mr. Cultra's. I have never had the least bother with excessive wear or nicking of the tappets or toes. We have, however, had some bother with the bolt that holds the two parts of the stem together.

I think that Mr. Cultra would overcome most of his trouble if he would ease off those sharp corners on the valves as he says, "they are as sharp as a knife edge." This knife edge scrapes the oil off, whereas if the edge were eased off the least bit it would give the oil a chance to get between the valve and seat. I have often done the same thing to a piston ring.

My only trouble has been with the steam valves on a Green engine. If the valves got dry or if any obstruction got in the way, the valves would not shut. I remember that once an accident happened to a dashpot and this kept the steam valve open (the closing not being positive but depending on the dashpot). The valve simply stayed open and in no way hurt the stem or the crosshead.

I have heard of links on the exhaust being broken by something getting caught in the valve. I should advise Mr. Cultra to look over the lifting studs (studs screwed into the tops of the valves to limit their lift off the seat), try the valves for side play, and above all ease off those knife edges.

Samuel H. Winterbottom.

Woonsocket, R. I.

Cause of Boiler Explosions

In the issue of Jan. 2, I note an article by D. M. Fraser on "Cause of Boiler Explosions."

I do not believe that air confined in a boiler while steam was being raised therein ever directly caused an explosion. I think it must be supplemented by some other cause to produce the effect, such, for instance, as Lester A. Fitts describes in the same issue under the heading, "Timely Discovery of Serious Lap Crack." If this had not been discovered it would probably have caused an explosion under the impulsion of a very slight shock, as may be caused by the presence of air entrapped in the boiler while getting up steam.

Victor Bonn.

New York City.

Isolated Plant Owners Responsible

In the Dec. 19 issue, I read the letter under the above head. In some establishments the power division is seriously neglected and very little attempt is made to determine whether the plant is operating as economically as possible. The engineer is not treated in the same way as are other department heads, as the latter are made responsible for the quality and quantity of the goods turned out and are given some say as to the materials used. To men who are capable of doing such work and assuming the responsibility, good wages are paid.

The engineer, on the other hand, is frequently hampered by being required to do his work with men he does not employ and whose scale of wages is not set by him. The coal is bought on the price basis, not on quality. He is often limited in the matter of cost of oil, waste and other materials. He frequently finds it impossible to get the owners to purchase such new machinery or apparatus as will assist him in keeping the plant in its best condition. He is frequently held responsible for the condition of the shafting and belting, besides the operation of

the engines and boilers. Yet, he is not allowed to use his judgment in the purchase of materials.

The first cost is frequently the only cost considered; operating cost is not considered except as it affects him. If his costs run high, he is blamed, and no excuses are accepted. The cause for high costs is frequently the inferior material which the purchasing agent or plant owner or manager purchases, directly against the judgment of the man who is held responsible.

The engineer is not paid in accordance with his responsibility. He is looked upon as merely an engine runner and as a necessary evil, and not as a manager of a most important part of the entire outfit. The owner well realizes that the successful operation of his plant depends upon its engine; but apparently he does not realize that in order to have the engine operating continuously and satisfactorily and have the power cost as low in this department as the operating costs are in any other department, he must pay good wages to his engineer.

Under these conditions, it is easy to see why the isolated plant is frequently taken over by the central station. Therefore, I heartily believe with Mr. Blanchard that the trouble is far more with the plant owner than with the engineer in many isolated plants. But I also believe that it is up to the engineer to do the best he can with the apparatus that is supplied, getting, when possible, additional apparatus and supplying to the plant owner or manager in as much detail as he possibly can the information he is able to collect. Show him from time to time its value and ask for apparatus which will enable him to give still more information, stating the reasons why. Such signs of interest will stimulate the owner and result in increased wages to the engineer and in decreased costs to the owner, and the engineer will be considered an important adjunct to the plant and treated accordingly.

The engineer should be given such information as will enable him to work out from month to month, or even from week to week, the power costs, including the fixed charges, as in many plants they are a very large portion of the power costs. This will also enable the engineer to supply the plant owner with figures to refute the central-station solicitors. It is not uncommon for the central-station solicitor to place a large value upon the initial cost of the plant, sometimes as high as $200 per horsepower, which in most cases is absurd. If the actual figures are known and are always on hand, no such fictitious value can be placed on the plant, and, therefore, the fixed charges cannot be made excessive.

Care should be taken also to determine the amount of power which would ordinarily be required to heat the plant so as to be in a position to state that the heating of the plant costs nothing, which may be true so long as all of the exhaust steam from the engine is used for heating; or that it costs a certain sum as additional steam is required beyond that which the engine can supply.

HENRY D. JACKSON.

Boston, Mass.

Cost of Power in New England Mills

From a casual perusal of the article by H. G. Brinckerhoff, under the above title, published in the issue of Dec. 19 it would appear that "wise men of the East" have discovered an independent steam power plant where the cost of one horsepower is $16.68 per annum, based on 53 working hours per week, and reference is made to a similar plant where, on the same basis, the cost is $14.57 per year.

The figures quoted may or may not represent superior economy compared with the performance of other plants, depending on whether the cost applies to 33,000 ft.-lb. per minute, actually delivered.

The high standing of the designers of the plant described is sufficient guarantee of the excellence of its appointments. But Mr. Brinckerhoff's statements are indefinite and misleading as to the cost per horsepower actually delivered, if the figure quoted for cost per horsepower per annum is based on gross indicated power without an estimate of any kind as to the indicated power lost in transmission and engine friction, and in driving the condenser pump, power-driven pumps, etc., all of which tend to reduce the amount of power actually delivered to the mill.

The author states that "The best electric-power transmission offer was in the neighborhood of $30 per kilowatt delivered on the switchboard in the mill," and that the installation of the independent power plant resulted in "$9140.02 saving per year over buying power, besides getting all heating." He estimates this saving on the erroneous assumption that indicated horsepower required to be developed by the engine in driving the mill must be the same as the electrical horsepower required to be laid on the switchboard, stating further that "In the calculation of difference of cost no reckoning is attempted to include the cost for electric power which would have been paid from the switchboard record for all the electrical losses in the motors and wiring beyond that point. * * *"

If it is assumed that the same actual or brake horsepower would be required for driving the same loads on the jackshafts, whether derived from motors or transmitted by belts from the engine, then the gross power indicated on the engine could not be the same as the electric power required at the switchboard, unless the losses in transforming electric power from the switchboard into actual power laid on the jackshafts were the same as the actual power, laid on the jackshafts by the engine, plus the loss in transmission plus the engine friction and the engine power employed in driving power pumps and other power-plant auxiliaries. Assuming, however, as in the article, that no reckoning is made against the electric drive beyond the switchboard, and that the losses beyond that point amounted to from 12 to 18 per cent. of the power at the switchboard, then, in order for a comparison on a basis of equality between indicated power with electrical power delivered at the switchboard, the author's conclusion could be had only on the hypothesis that such losses by engine power as belt transmission, engine friction, belted pumps and other power-plant auxiliaries, not only amount to less than from 12 to 18 per cent., but that they amount to nothing.

If Mr. Brinckerhoff can obtain data from actual tests which will show the average amount of actual or brake horsepower supplied to the jackshafts of the Fitchburg Yarn Co., and compare that average with the actual cost—which is the logical method of estimating the cost of power used by a manufacturing establishment—the results, judging from the data thus far given, will still reflect credit on the designers of the plant, but the cost per annum, per horsepower delivered, will be considerably in excess of $16.68.

FRANKLIN VAN WINKLE.

Paterson, N. J.

What Means the Dome?

The article and cut in the Dec. 26 issue pertaining to the high dome on a locomotive discovered in the jungle of an abandoned lumber camp in the South interested me. Possibly the reason for the dome was to get dry steam; as undoubtedly the throttle valve is in this dome. One of the handicaps of the large locomotive on trunk lines is the low dome due to lack of head clearance, resulting in wet steam and hence bringing about the necessity for superheaters which are complicated and bulky for a locomotive on which it is necessary to cluster the many attachments to the boiler like barnacles on a ship.

The high dome on this logging engine may have been used to furnish dry steam to a pump or to drive a sawmill engine as on the side of the dome a pipe connection can be seen.

The writer fired locomotive engines in the early eighties, the boilers being about 42 in. in diameter, and the dome was about 48 in. high, which gave good re-

sults with dry steam and minimized the possibility of priming.

With new main-line equipment the boiler is so large that it requires to be placed above the wheels, raising the boiler still nearer to the clearance line, and thus it can be seen that while the size of boiler is increasing that of the dome is decreasing.

JOHN FRANCIS.

Birmingham, Ala.

The Delray Boiler Tests

I noted with interest the results of "Tests of World's Largest Boilers," as given in the abstract of Dr. Jacobus' paper in POWER for Dec. 5. The two series of tests as presented seem decidedly remarkable both for the high efficiency obtained and for the uniformity of evaporative results. The tests show beyond any doubt that these boilers will give satisfactory results under normal working conditions when a varying load is unavoidable.

The expectations of the designers seem to have been realized to a very considerable extent in regard to the reduction of losses per unit of power generated, and the probable better combustion of the fuel supplied, all of which is traceable to the departure from what has been previously considered conventional design for furnace construction. In these boilers the hottest gases are brought into contact with a comparatively small portion of the setting wall and with a large area of heating surface, and in turn the larger portion of the area of the setting wall is in contact with cooler gases. The relatively large volume of the space directly over the fire is also noticeable, where the gases may mix and burn before coming in contact with the boiler tubes.

I do not quite see how so high a rate of combustion is obtained with the draft as shown in the results given.

C. W. BELL.

Scranton, Penn.

Knocking in Air Compressors

The communication of C. R. McGahey about "Knocking in Air Compressors," on page 902 of the issue of Dec. 12, seems to challenge criticism. The knock which occurs somewhere about mid-stroke in "straight-line" compressors is decidedly not "caused by the elastic spring of the air in the air cylinder acting against the steam piston when the steam is expanding, due to the cutoff," and it is not to be cured by changing the cutoff, which should be adjusted to suit the steam pressure and load.

The knock is caused by the reversal of the driving forces which occurs when the steam power becomes less than the air resistance and the flywheel, instead of being driven, becomes the driver. The only thing apparently to be done about it is to keep the main bearings and the connections with as little slack as possible, and especially to have no vertical play between the crosshead and its upper and under slides.

As to the slight difference which may be found in the lengths of the two connecting-rods, these do not generally make any trouble, because the crosshead in this type of compressor is switched in the middle. If your correspondent had taken off both of the connecting-rods and, accidentally or otherwise, had shoved the end of the crosshead forward or backward, he might easily have found a difference of an inch or two instead of the sixteenth of an inch reported.

FRANK RICHARDS.

New York City.

Feed Water Regulators

Some time ago in an editorial the questions were asked, "What is the use of a feed-water regulator? What is the use of keeping the water level constant?"

A reliable regulator protects the boiler and maintains a steam space of uniform volume, thus tending to produce steam of uniform quality. Another point in favor of the regulator is that it tends to maintain the steam pressure under sudden fluctuations of load, although a belief to the contrary seems to prevail among engineers. A sudden increase in the load causes the water level to rise slightly and this in turn causes the regulator to decrease or cut off the feed to the boiler, while a sudden drop in the load causes a depression of the water level and instant action on the part of the regulator to increase the rate of feed to the boiler.

I believe that a good regulator is almost indispensable and that a poor one is a thing from which to steer clear. A few years ago the engineer in one of the large packing houses in the West related the following to me:

"We have 24 boilers equipped with automatic stokers and feed-water regulators. Once, in our refrigerating plant, which adjoins the power plant, an ammonia tank burst, killing one man and driving everyone from the building, and for more than an hour and 40 minutes no one could get into the boiler room. If we had been without feed-water regulators probably nothing could have saved the boiler plant as the stokers kept up a steady fire during that time."

This suggests one point decidedly in favor of feed-water regulators. Admitting the possibility of all machinery to become deranged, it still must be conceded that a device carefully thought out, designed according to established mechanical and scientific principles and constructed of good material is at a critical moment far more reliable than the average man. Yet, all such automatic machinery requires intelligent attention to see that it is kept in working condition so that when the critical moment does come it may not be hindered because of some loose bolt or dry bearing.

Some engineers believe that the automatic regulator causes the firemen or water-tenders to become careless, but my personal experience has led me to believe just the opposite.

I look on the feed-water regulator as a good investment. A good one will usually save from one to four times its costs in a year and the little outlay for it may at some time be the means of saving the plant.

C. L. JOHNSON.

Newark, N. J.

Engineers' Wages

To be a successful engineer, one must have a grounding in the mechanical trades, such as those of the machinist, steam fitter, boiler maker, etc. In any one of these trades alone the pay is more than double that of the average engineer in certain sections of the country.

Take my own case, for example. I have been making a study of engineering now for eight years; I have worked hard and done the best I could for all of my employers and I am getting very poorly paid for it. Now, one might say, "Why doesn't he look for something else at which he can earn more?" This is all well and good, but I like the engineering business best and I know that we will get higher wages soon.

A barber, dentist, bookkeeper, or man of similar calling can learn his business in two or three years and at the end of that time draw a good salary. An engineer has to study almost a life time, and he gets just a common laborer's wages.

Some wonder who or what is responsible for this state of affairs. The answer is, the engineer himself. Engineers should stand up for their rights and demand a standard wage for each class of engineer. What we all want are an eight-hour day and more salary. Then we can do better work.

In some steam plants they hire a couple of good engineers and a lot of common laborers, and put the latter to work around the engines, boilers, etc.; they are paid about $45 or $50 a month. After a month or so these men call themselves engineers and they hardly know a boiler from a water cistern. These are the men who are killing our opportunities. What we want is a good organization, with all of the engineers in the country as members; then we can go out and fight for what we deserve.

HENRY H. CARTER.

Milwaukee, Wis.

Figures for Mr. Fitzgerrell

In the Dec. 26 number, H. S. Fitzgerrell asks for the size of a tank which when placed in a stream running at 6 miles per hour will cause the water to flow out of the pipe which is connected to the end of the tank and extends 50 ft. above the surface of the stream.

According to the laws of hydraulics, the size of the tank will have no effect on the height to which the water will be forced in the pipe as the height of the rise depends wholly on the velocity of the stream or, in other words, the pressure per unit area, and not the total pressure, on the end of the tank.

In this case the pressure in pounds per square foot in the tank will be

$$P = \frac{V^2 62.5}{2g}$$

where

P = Pressure in pounds per square foot;

V = Velocity of stream in feet per second;

g = Acceleration due to gravity = 32.2.

Since the velocity of the stream is 8.8 ft. per second, we have

$$P = \frac{8.8^2 \times 62.5}{2 \times 32.2} = 75.1 \text{ lb. per sq. ft.}$$

This will cause the water to rise $\frac{75.1}{62.5}$ or 1.2 ft., or about 1 ft. 3 in. The water would rise just as high in the pipe if the tank were removed.

The velocity of the stream necessary to cause the water to flow out of the pipe 50 ft. high would be about 57 ft. per second, or 39 miles per hour, neglecting friction.

WILLIAM BRUNKER.

Chicago, Ill.

The apparatus shown by Mr. Fitzgerrell is nothing more than a pitot tube and as such the height to which the water can be lifted is equal to a constant multiplied by the square of the velocity in feet per second and divided by $2g$. The constant varies from 1 to 2, and for a tube of the shape shown it would be very near to 2. In this case the velocity of the water is 6 miles per hour or 8.8 ft. per second. The solution would be as follows:

$$h = k\frac{v^2}{2g} \qquad 2\frac{(8.8)^2}{64.4} = 2.4$$

from which it would appear that the maximum height to which the water could be lifted would be 2.4 ft.

If a place could be found having a fall of a few feet, a hydraulic ram would be the cheapest and easiest means of raising the water to the desired height.

W. L. DURAND.

Brooklyn, N. Y.

The height to which the water will rise depends on the pressure per square inch at the lowest part of the tube, which in turn depends on the rate of flow at that point, or

$$V^2 = 2GH$$

$$H = \frac{V^2}{2G}$$

In other words, H equals the height through which a body must fall to attain a speed of V ft. per second, neglecting all friction. A velocity of 6 miles per hour = 8.8 ft. per second.

$$H = \frac{8.8 \times 8.8}{2 \times 32} = 1.2 \text{ ft}$$

The height to which the water in the tube will rise is independent of the size of the tank, and will stand only 1.2 ft. above the surface of the river at the given rate of flow. A check valve is of no use whatsoever.

D. FLIEGELMAN.

Holyoke, Mass.

To solve this problem we may use the well known formula,

$$\text{Kinetic energy} = \frac{WV^2}{2g}$$

and for convenience we will assume 1 lb. to represent W, the weight of water. The water is flowing at the rate of 6 miles per hour, which is equivalent to 8.88 ft. per second, the value of V. The acceleration due to gravity or g equals 32.2. Then,

$$\text{Kinetic energy} = \frac{1 \times 8.88^2}{2 \times 32.2} = 1.2 \text{ ft.-lb.}$$

Consequently, 1 lb. of water flowing down the river at a speed of 6 miles per hour would have a kinetic energy of 1.2 ft.-lb., and 1 lb. raised vertically 1.2 ft. would require 1.2 ft.-lb. Therefore, the water would rise 1.2 ft. in the 2-in. pipe in the case under discussion. Friction has been neglected in the foregoing.

The size of tank and the check valve have nothing to do with the problem.

J. C. CALLERY.

Hamilton, Ohio.

Neglecting the losses due to friction, eddies, etc., the height to which the water will rise may be calculated from the formulas for falling bodies,

$$t = \frac{1}{g} \text{ and } H = \frac{g}{2}t^2$$

in which

H = Height to which the water will rise;

t = Time in seconds;

g = Acceleration due to gravity = 32.16;

v = Velocity in feet per second.

The stream flowing at the rate of 6 miles per hour gives a velocity of 8.8 ft. per second; therefore,

$$t = \frac{v}{g} = \frac{8.8}{32.16} = 0.27 \text{ sec.}$$

Substituting,

$$H = 16.08 \times 0.27^2 = 1.17 \text{ ft.} = 1 \text{ ft. } 2 \text{ in.}$$

In actual practice the height would be considerably less, owing to various losses.

H. A. MUNYAN.

Syracuse, N. Y.

[Additional contributions on this subject were received from L. Johnson, J. Hart and O. Kuhneman.—EDITORS.]

Christie Air Steam Engine

In the Dec. 19 issue, George L. Sullivan mentions making a report to one of his clients on the Christie engine. His conclusions are undoubtedly correct and are admirably summed up in his last paragraph, but how he arrives at any conclusion at all, with his manner of reasoning, is more than I can understand.

He says: "When the steam valve opens, the boiler, steam pipe and engine cylinder become one vessel and a rapid diffusion of the air takes place into the steam pipe." If this statement were correct, it would put all gas and gasoline engines into the scrap-pile, for when the inlet valve opens the cylinder and the open air "become one vessel" and the diffusion would fill the engine room with dangerous vapors.

If the air were to diffuse into the steam pipe, there would be no harm done; in fact, I imagine an ordinarily good engineer, with plenty of horse sense, in designing an air-steam apparatus would use a common air compressor and pump the air into the steam space in the boiler or into the steam pipe. This would serve to keep condensation out of the steam pipes as well as the engines connected with them.

Mixing steam and air together does not change their pressure or temperature. If pure steam has to be expanded to a complete vacuum to get all of the work out of it, then the air-steam mixture will not give up all of its energy with a less expansion. The only advantage of mixing air with steam is the lowering of the saturation point, which prevents condensation in the cylinder. This is a great advantage and well worth considering, but this same lowering of the saturation point makes it impossible to use a condenser unless some new system of condensing be discovered—possibly some kind of absorption system similar to that used in ice making would do the work.

Of course, the promoters appear to prove that the air-steam is exhausted into the open air at a much lower pressure than the air itself, but this is true only in a technical sense. The same line of reasoning from Dalton's law would show that the pressure of the open air is much lower than it actually is, for the air is a mixture of several gases, and is not the pressure of each gas the same as it would be were there no other gases in existence?

FRED BOONE.

Davidson, Okla.

Inquiries of General Interest

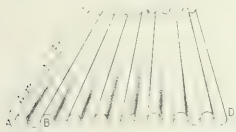
Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Heating Surface of Corrugated Flues

How is the factor 4.93 obtained in the rule to determine the heating surface of corrugated flues?

F. A.

Supposing the flue to be cut horizontally and straightened out as shown in the illustration, there would be a sheet of corrugated metal the width of which would be the mean circumference of the tube; that is, the mean diameter times 3.1416. Each corrugation is practically



SHEET OF CORRUGATED METAL

a half circle to either side of the mean diameter so that the length of the sheet from *A* to *B* is equal to the circumference of the dotted circle in the illustration. The length that it actually occupies in the corresponding length of a flue is *ab*. The length of the flattened sheet is therefore to the length of the tube as 3.1416 is to 2, or the length *AE* of the straightened sheet would be

$$\frac{3.1416 \times L}{2}$$

where *L* equals the length *AD* of the corrugated flue. Since the surface is the length multiplied by the width, the area is

$$\frac{3.1416 \times L}{2} \times D \times 3.1416 \text{ or } \frac{3.1416^2 DL}{2}$$

$$= 4.93 \times \textit{diameter} \times \textit{length}$$

Resistance of Copper Wire

Two wires contain 100 cu.in. of annealed copper; one is a round wire 0.5 in. in diameter and the other is square, 0.5 in. on a side. Which wire has the greater resistance?

C. E. N.

The round wire has the greater resistance because its cross-section is smaller, and its length must be greater for the same weight. The cross-sectional area of the round wire is 0.19635 sq.in., and its length would be

$$\frac{100}{0.19635} = 509.3 \textit{ in.}$$

The cross-section of the square wire would be

$$0.5 \times 0.5 = 0.25 \text{ sq.in.}$$

and its length would be

$$\frac{100}{0.25} = 400 \textit{ in.}$$

long. The resistance of a soft copper rod 1 sq.in. cross-section is about 0.00000069 ohm per inch of length. To determine the resistance in ohms of a copper conductor, multiply the quotient of the length divided by the cross-section in square inches by 0.00000069. The resistance in ohms can also be determined by multiplying the quotient of the volume in cubic inches divided by the square of the cross-section in square inches by 0.00000069. Thus the resistance would be:

For the round conductor

$$\frac{509.3}{0.19635} \times 0.00000069 = 0.0017897 \textit{ ohms}$$

For the square conductor

$$\frac{400}{0.25} \times 0.00000069 = 0.001104 \textit{ ohms}$$

Substituting figures to the second rule, it would be thus expressed:

For the round conductor

$$\frac{100}{0.03855334} \times 0.00000069 =$$

$$0.0017897 \textit{ ohms nearly}$$

For the square conductor

$$\frac{100}{0.0625} \times 0.00000069 = 0.001104 \textit{ ohms}$$

Feed Water Heaters

What is the difference between an open and a closed feed-water heater?

H. H.

An open feed-water heater is one in which the steam and feed water mingle, and the steam in condensing gives up its heat directly to the water. Closed heaters are those in which the steam and water are in separate chambers, and the steam gives up its heat to the water by conduction.

Lap of Corliss Engine Valves

Why is lap given to the steam valves of Corliss engines?

A. K. L.

If the eccentric could be run at right angles with the crank, only sufficient lap to insure the valves being tightly closed would be necessary. To get a sufficiently early opening for release and closure for compression, the eccentric must be advanced; this would pull the steam valve open before the crank got to the center, and enough lap is added to cover the port until the desired lead is obtained.

Throttling and Automatic Governors

What is the difference between a throttling and an automatic governor?

H. H.

A throttling governor regulates the speed of the engine by changing the steam pressure as it enters the cylinder, in accordance with the load. An automatic governor regulates the speed by cutting off the supply of steam at various points of the stroke, in accordance with the load and pressure. With a throttling governor, the volume of the steam is constant and the pressure varies. An automatic governor permits the steam to enter the cylinder at the highest available pressure, and the volume is varied to meet the requirements of the load.

Braces for Boiler Head

How many braces 1 sq.in. cross-section would it take to brace a 60-in. boiler for 80-lb. pressure, where the top row of tubes is 5 in. above the center?

A. W. T.

Assume a space 2 in. wide above the tubes and 2 in. wide around the edge being supported by the tubes and flange. The height of the circular segment to be braced would be

$$30 - (5 + 2 + 2) = 21 \textit{ in.}$$

The diameter of the circle of which it is a part is

$$60 - (2 \times 2) = 56 \textit{ in.}$$

therefore, the area to be braced is 843.61 sq.in. The pressure on the surface would be

$$843.62 \times 80 = 67{,}489.60 \textit{ lb.}$$

If one brace sustains 6000 lb., it will take

$$67{,}489.60 \div 6000 = 11.2 \text{ or } 12 \textit{ braces.}$$

Effective B.t.u. in Producer Gas

What are the effective B.t.u. in producer gas and how are they to be found?

C. B. S.

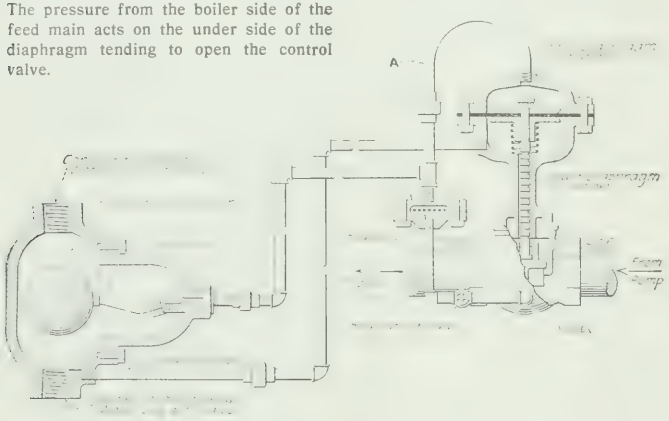
The effective heat value is equal to the total heat units per cubic foot minus the heat units that will be carried off in the steam made from the hydrogen in the gas when the latter is burned. This heat is usually deducted by considering that the available heat liberated by combustion of the hydrogen in the gas will be only 51,700 B.t.u. per pound of hydrogen instead of the full value of 62 000 B.t.u.

New Hydrostatic Feed Water Regulator

Some weeks ago we published an editorial on feed-water regulators. We pointed out that it was highly desirable that the flow of water to the boiler be not entirely interrupted.

The "Watch Dog" feed-water regulator here described is so designed that the feed-water flow is never entirely cut off except when the boiler is delivering practically no steam. The principle upon which it operates may be discerned by referring to the accompanying figure.

For water to flow to the boiler it is necessary that the pressure in the feed main on the pump side of the controlling valve be slightly higher than on the boiler side. In the "Watch Dog" regulator a diaphragm is attached to the disk of the control valve by means of a spindle working through a stuffing-box. The pressure from the boiler side of the feed main acts on the under side of the diaphragm tending to open the control valve.



THE "WATCH DOG" FEED-WATER REGULATOR

The pressure in the pipe *A* acts on the upper side of the diaphragm, tending to close the valve. This pressure depends upon the pilot valve which is controlled by the float. As the pilot valve approaches the closed position, the pressure on the upper side of the diaphragm approaches that in the pump side of the feed main, over-balances the pressure on the under side of the diaphragm and causes the control valve to close slightly and reduce the rate of flow to the boiler. As the float falls the pilot valve is opened a little wider and the opposite results are produced.

The claims made for this regulator may be summed up in the four words, efficiency, reliability, simplicity and durability.

The L. J. Wing Manufacturing Co., West and Albany Sts., New York, manufactures the "Watch Dog" feed-water regulator.

Sauer Adjustable Shaft Bearing

An adjustable shaft bearing which provides means for compensating for wear and insuring a proper alignment of the shaft by using a set of bearing members or blocks adjustable in a radial direction has been placed on the market by the Sauer Power Generating Co., 5115 to 5119 Rosetta St., Pittsburg, Penn.

The special advantages claimed for this bearing are simplicity of construction, easy adjustment of center and side motions while running and the elimination of liners, oiling grooves and shaving or fitting. Fig. 1 is a view of the bearing ready to be placed on the shaft.

The bearing consists of a casing or shell suitably supported and a sleeve having several slots fits loosely around the shaft. The bearing blocks are inserted in these slots, as shown in Fig. 2, to slide freely therein and be adjustable relative to the shaft. At one end of the shell a thimble is placed between it and the bearing block and the engaging surfaces between these three parts are so arranged that the distance between the blocks and the shafts is regulated by the position of the thimble.

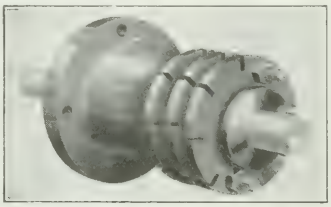


FIG. 1. ADJUSTABLE SHAFT BEARING

The preferred construction is to make the bearing blocks wedge-shaped with their outer faces at an angle to the axis of the shaft, rounded and tapering toward the end of the shell engaging the thimble. The bore of the thimble, shown by the dotted lines in Fig. 3, is tapered to correspond to the outer faces of the bearing blocks. This thimble is threaded externally and the bearing shell internally so that the threads engage, and by

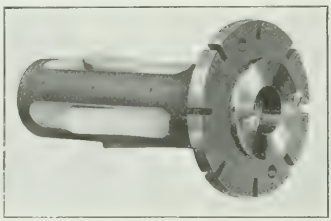


FIG. 2. TAPER SLEEVE WITH BEARING BLOCKS IN PLACE

rotating the former the bearing blocks are adjusted accurately to insure a proper engagement with the shaft and to compensate for wear. To turn the thimble more conveniently an annular flange *B*, Fig. 4, is provided at its outer end, enabling the thimble to be engaged with a spanner or wrench.

The threaded ring *A* set on the thimble

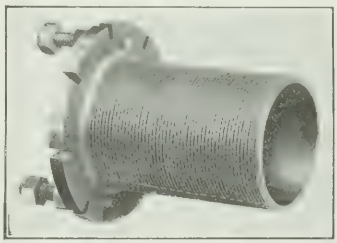


FIG. 3. THE THIMBLE BORE SHOWN BY DOTTED LINES

can be used to screw up against the end of the shell after the thimble has been adjusted as a locknut to prevent displacement. Another means provided for locking the thimble consists of the annular flange *C* on the end of the sleeve

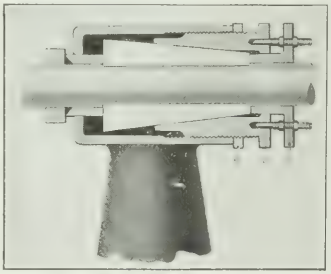


FIG. 4. SECTIONAL VIEW WITH BEARING IN PLACE

surrounding the shaft through which a number of bolts pass. These bear against the flange *B* on the end of the thimble and are held in place by nuts on each

side of the flange, which serve to force the bolts against it and lock them in place.

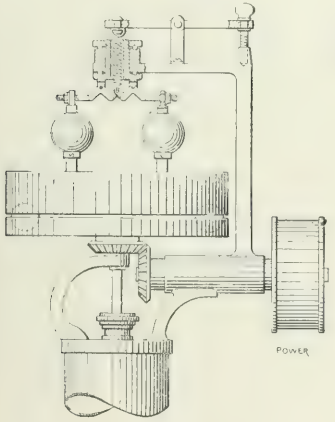
At the opposite end of the shell there is an annular flange extending inwardly and fitting on the sleeve surrounding the shaft. The space inclosed by this flange is utilized for storing oil to lubricate the bearing, and this may be fed into the chamber from a tank through a pipe tapped in the shell of the bearing. The oil passes from this space to the shaft through apertures in the portions of the sleeve between the bearing blocks, which are clearly shown in Fig. 2. Drippings of the lubricating oil may be drawn off from the bottom of the shell by another pipe and fed back into the tank by a pump or other device of this nature.

In use the center adjustment is secured by loosening the locknut *A* and turning the inside tapered sleeve or thimble in Fig. 3 as the running fit requires. To adjust the side motion the nuts on the flange of the sleeve *C* are tightened. The only wearing parts of the bearing are the adjustable blocks shown in Fig. 2, which are made either of babbitt metal or bronze.

As side friction on the bearing wears only one block at a time, it is possible by turning the sleeve to have all the blocks successively assume the position of greatest wear and wear them all down equally. New blocks can be easily set in position when the old ones wear out, as no special skill is required.

Governor Tension Adjusting Mechanism

Patents have recently been granted to Charles Grant, of Wilmington, Del., on



GOVERNOR AND TENSION-ADJUSTING MECHANISM

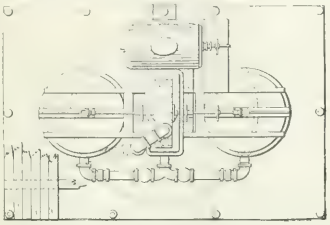
a governor tension adjusting mechanism, the design of which is shown in the accompanying figure.

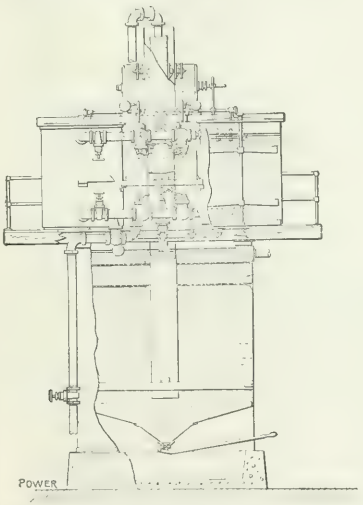
The centrifugal force developed by the revolution of the ball weights is counteracted by a spring connected to the weights by a set of links and bell-cranks. The bell-cranks are supported by a hollow ball bearing supported by an arm from the base as shown. The spring passes through the hollow center of this bearing and is attached by a swivel to one end of an adjusting lever.

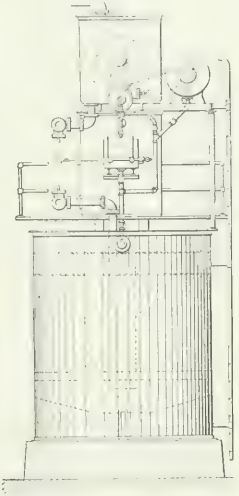
The tension of the spring may be adjusted while the governor is in motion by the simple process of manipulating the thumb-screw at the other end of the lever.

An Automatic Water Purifying System

The purification of water for boiler-feed and industrial purposes is quite essential in many plants. There are numerous machines and devices on the market for this purpose and the selection of one for any particular case is largely a matter of the cost of installation and operation.







THE LORD COMPANY'S AUTOMATIC WATER-PURIFYING APPARATUS

The George W. Lord Co., Philadelphia, Penn., has recently put on the market an apparatus for water purifying which is entirely automatic in its operation and which may be installed for a comparatively moderate price. The apparatus consists principally of one large settling and filtering tank, two mixing tanks, one chemical storage tank and two measuring chambers.

The incoming water first passes over a waterwheel which furnishes the power to operate paddles in the mixing tanks and chemical storage tank. From the wheel the water flows to either one or the other of the two mixing tanks directly below, where it comes in contact with the chemicals flowing by gravity from the chemical storage tank. The solution of chemicals is measured out by an automatic measuring valve and the speed of operation varies with the flow of the water. Hence, the correct amount of chemicals is mixed with the water no matter what the rate of flow may be.

From the mixing tanks the water flows to the bottom of the settling and filter tank through a large cylindrical tube, where it drops the bulk of the precipitates formed into a cone-shaped hopper bottom of the tank. These precipitates can be removed by a sludge valve designed for this purpose. The water then rises and after passing through an excelsior filter near the top of the tank flows off through the outlet pipe at the top.

The inlet and outlet pipes of the two mixing tanks are controlled by lever valves which are automatically operated so as to cause the water to flow first into one and then into the other of the tanks. These valves, as well as the chemical measuring valve, are operated by means of sets of levers which are shifted by a dumping bucket, the latter operated by the weight of water run in from overflow pipes.

A float valve in the inlet pipe, operated by a float in the filtering tank, controls the entire operation of the apparatus.

Locking Device for Canton Shaking and Dumping Grate

The Canton shaking and dumping grate, which is manufactured by the W. H. Allman Co., Canton, Ohio, is shown in Fig. 1, which also illustrates the quadrant that provides a means for locking the grate members in a smooth, even position, as shown on the near side.

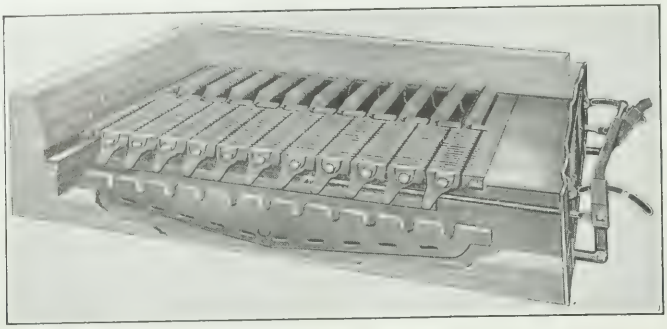


FIG. 1. GRATES IN A LOCKED AND OPEN POSITION

The grate sections are operated by a horizontal rod which is attached to a projection extending from the shaking-rod connection. The shaking-arm in the front of the furnace is made hollow to receive a hand lever. This lever is made as shown in Fig. 2 and has a projection on one side at the end. A curved piece having shallow recesses cast on one side is attached to the furnace front and passes through a suitable hole in the head of the shaking-arm. This serves as a guide to the arm when operating the grate and also as a locking member.

Between the shoulders formed on one side of the curve piece there is an opening. When the grates are flat, the boss on the shaking handle will pass down through this opening until it is in a position to slide along the bottom of the curved member. The grates can then be shaken. A pin in the curved member prevents the grate from being dumped when shaking the fire. Removing the pin permits the grate to be dumped by pulling the lever to its extreme travel.

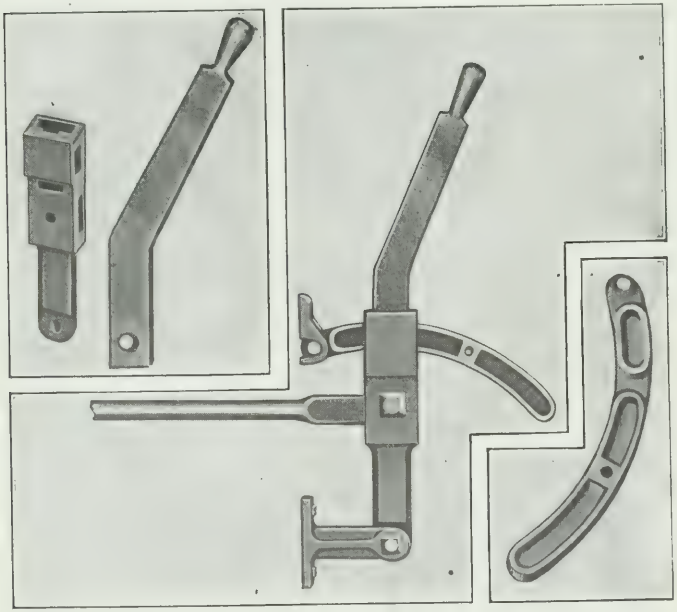
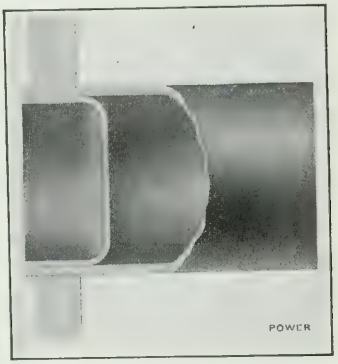


FIG. 2. DETAILS OF THE LOCKING DEVICE

Before the shaking lever can be removed from the head of the shaking-arm, it must be pushed forward to its extreme travel, when the grates will be level and in their proper position. Then the shaking lever can be removed, but not before. With this arrangement a careless fireman cannot leave the grate partly closed with the ends sticking up in the fire and unburned fuel falling into the ashpit.

Minute Emergency Expansion Plug

The Max Machine Co., Clinton, Mass., has recently placed on the market an emergency plug for plugging the ends of tubes in return-tubular boilers, in case they suddenly give out, thus permitting the boiler to be kept in service until opportunity permits of a permanent repair.



MINUTE EMERGENCY EXPANSION PLUG

These plugs are made in four sizes, which vary about $^{10}/_{100}$ in. in diameter, to accommodate the difference in the diameter of the tubes. When a tube leaks a pair of plugs are selected which will drive hard in the ends. They are inserted as shown in the accompanying illustration. Should the plug leak it can be made tight by peening with a hammer.

Rotary Gate Valve

For lack of room it is frequently impossible to use the straight gate valve where conditions of service make its use desirable. In such an event the Rothchild rotary-gate valve, which is illustrated herewith, might be the solution to a bothersome problem, not that economy of space is the only feature which this valve has to recommend it.

The Rothchild rotary-gate valve is an angle valve, the feature of which is two concentric cylinders, one of which is stationary, forming the seat, and the other revolving, forming the gate. When the ports in the two cylinders are in line the gate is open and the fluid passes through the gate in the direction of the arrow shown on the side of the body. To close the valve, the gate or outer cylinder is

revolved 90 degrees, thus covering the ports in the seat.

The gate is cut into halves to admit of the fluid in the valve exerting sufficient pressure between the gate and the seat to prevent leakage. When the two halves of the gate are fitted over the seat there is a gap of ⅛ inch between the two halves to prevent them from touching each other and thus insuring a good bearing between the gate and the seat.

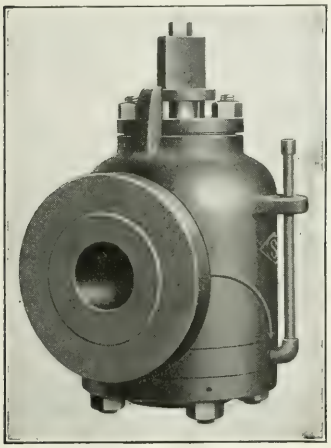


FIG. 1. ROTHCHILD ROTARY GATE VALVE

The fork for operating the gate engages the lugs shown on each half and exerts only sufficient pressure on the gate to insure its always being in contact with the seat, whether the valve is open or shut. On top of the stem there is a nut on which the operating lever is fitted. This nut also has a heavy lug on it which strikes the lugs shown on

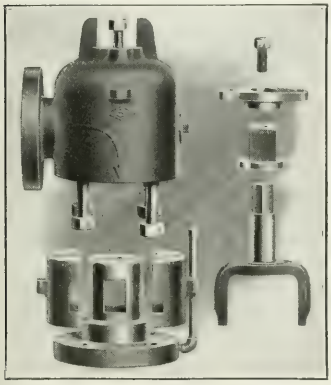


FIG. 2. DETAIL PARTS OF VALVE

the body of the valve to indicate that the valve is wide open or shut. The collar or boss on the fork is, of course, ground tight with the under surface of the gland.

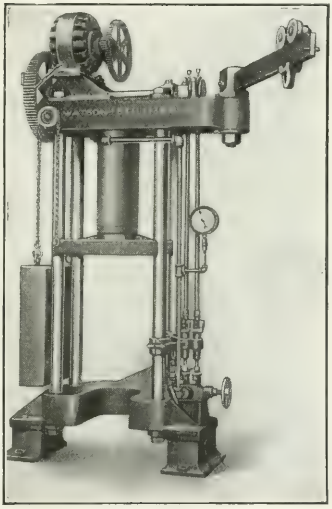
The small pipe tapped into the flange of the valve seat is for forcing lubricant, by means of a compressed grease cup, along a groove on each side of the seat. It is obvious that this valve cannot be jammed shut or open. This construction provides such an exceptionally large bearing surface between the gate and the seat that the amount of cutting necessary to make it leak is proportionally greater than with valves having smaller bearing surfaces.

The working parts of this valve are unaffected by any of those strains in the piping which tend to distort the body of the valve and in time produce leakage. These valves remain tight under the most unfavorable conditions and are particularly valuable for boiler-blowoff service when a leaky valve is not only troublesome but also a source of loss of much energy.

The Rothchild rotary-gate valve is manufactured by the John Simmons Company, 110 Center street, New York City.

Hydraulic Press

The hydraulic press illustrated herewith is useful for broaching, keyseating, putting gears on shafts, pressing bearings, handling mandrels and general work where heavy pieces are to be forced together.



HYDRAULIC PRESS

A crane bracket and beam are extended from one end so that the work may easily be swung into the press. A back-geared motor mounted upon the pedestal on top of the press drives the pump shaft. Upon the other end of this shaft are two pump eccentrics. The pump pistons are both ¾ in. in diameter by 2 in. stroke. The pedestal legs act as a reservoir for the pump.

The operating valve shown is a single-screw stem valve which releases the pressure from the work when open and starts the ram down when closed. A safety valve is used in connection with the pump to stop dangerous overload. The press is made in two sizes, 80 and 100 tons capacity respectively, and is also made hand or belt driven. This press is built by the Watson-Stillman Co., 50 Church St., New York City.

Power System of the Brakpan Mines, Ltd.

BY S. R. STONE

An interesting example of the application of modern scientific methods to regulation of the power consumption of a mine and ore-reduction plant is afforded by the arrangements recently completed on the property of the Brakpan Mines, Ltd.; near Johannesburg, South Africa. Here power is purchased from the Victoria Falls & Transvaal Power Co., which in turn buys the surplus water from the shafts; and a close check is kept upon the rate of current consumption in each part of the plant by means of separate metering. This enables the management to ascertain whether the use of power at any point is excessive and to determine, through experimental changes, where economies can be effected.

All of the equipment in or about the mine and ore-reduction plant is electrically operated, the division of motors being about as follows: mine pumping, 1500 hp. or less; underground haulage and surface tramming, 400 hp.; hoists, 4500 hp.; crushers, stamps, tube mills, etc., 2200 hp.; mill and cyanide-plant pumping, 1000 hp., and the remainder for various minor purposes. The total estimate of motors required for operation at the full capacity planned approximates 10,000 hp., but the allowance made for this has been liberal and the actual current consumption in regular service is low. At the same time there is sufficient steadiness of operation to insure good power and load factors. The current is transmitted to two transformer and converter stations, one at each hoisting shaft. Distribution is at 2100 and 500 volts, according to the character of the service, all lines being carried as underground cables, of the paper-insulated, lead-covered, armored type. For the most part, these are laid and connected on the ring system, enabling the supply to any part to be maintained in case of individual breakdowns or any part to be isolated when necessary without interruption to the rest of the service. There is a very extensive lighting system, both above and underground. Of the three electric hoists installed, two are supplied through flywheel motor-generator sets, on the Ilgner system, with Ward Leonard control, and one is driven without any balancing apparatus, from an alternating-current motor with external resistance for speed variation. The capacity of each hoist is stated as 100 tons per hour, based on a vertical depth of 3800 feet.

A Correction

In the description of the Burt induced-draft ventilator, on page 134 of the Jan. 23 issue, the address of the Burt Manufacturing Co. was inadvertently given as Cleveland instead of Akron, Ohio. The error will, of course, be recognized by many of our readers, and we trust that the above correction will reach those who are not familiar with the address of the company in time to avoid any serious confusion or inconvenience.

Water Power Development Utilizing a 2985-Foot Head

The *Engineering News* for Dec. 28, 1911, contains an interesting description of the Adamello water-power development which supplies power to the city of Milan, Italy. The water supply is taken from the rivers Oglio and Paglia and Lake d'Arno, all of which are fed from the glaciers of the Adamello Mountains, and is led to two power stations, one at Isola and the other at Cedegolo.

The distinguishing feature of the system is the extremely high head, 2985 ft., under which the Isola station operates. In order to have the necessary water-carrying capacity with minimum loss of head, and yet provide adequate strength without making the pipe thickness unduly large, it was decided to lay two parallel supply-pipe lines to the power house. The top section of these pipe lines from the penstock to a point where the static head reaches 722 ft. consists of riveted pipes 31.5 in. in diameter with walls 0.28 to 0.55 in. thick. The next section of the line consists of lap-welded pipes with double-riveted sleeve joints; and the final section near the power house at which point a minimum diameter of 22 in. is reached, is made up of lap-welded pipes 1.26 in. thick with welded-on flanges recessed to receive rubber packing. Before putting these pipes into place they were subjected to a pressure of 4000 lb. per square inch, or about three times the working pressure.

Each pipe delivers 35.3 cu.ft. per second and the total loss of head is only 79 ft., or about 2.6 per cent.

The turbines are each fed by a single jet, and regulation is effected by means of a deflecting nozzle connected with the governor. A pear-shaped needle within the nozzle regulates the area of the opening and the quantity of water required for the turbine. Should a large reduction in load occur suddenly, the governor causes the nozzle to swing so that the jet clears the bucket. The regulator then begins to close the opening by means of the needle and to swing the nozzle back. In this way, any shocks incident to a sudden change in load are averted.

The Isola station is laid out for seven 6000-hp. turbines running at 620 r.p.m., although at present only five are installed. Each is direct-connected to a three-phase, 40-cycle, 12,000-volt generator from which current is delivered to the Cedegolo station, where it is stepped up to 60,000 volts for transmission to Milan.

The Cedegolo station is similar in many respects to the Isola station, but utilizes a head of only 1542 ft.

A Swedish Hydro-electric Power Station

Engineering, of Dec. 22, publishes a description of the Gullstang hydro-electric power station in Sweden. Francis double-flow turbines are used under an effective head of 20 m. (about 66 ft.).

Running at 250 r.p.m., the 4000-hp. units have a guaranteed efficiency of 79 per cent. at full load, 78 per cent. at three-quarters load and 72 per cent. at half load. The 4500-hp. unit has a guaranteed efficiency of 78, 79 and 72 per cent. respectively at the loads above mentioned. For each per cent. that the efficiency is short of the guarantee the manufacturers agree to pay a penalty of 2000 kr. ($536) per turbine, and for each per cent. by which the efficiency exceeds the figures of the guarantee, the manufacturers are to have a premium of 1500 kr. ($402) per turbine.

The turbines are actually run at 265 revolutions. The cost of installation, based upon the three 4000-hp. and one 4500-hp. units already installed, is 192 kr. ($51.46) per horsepower installed, and 265 kr. ($71.02) exclusive of reserve. When the station is fully completed it is expected that the cost will be reduced to 138 ($36.98) and 167 ($44.76) kr. respectively.

Increase in Oil Production

The production of petroleum in 1911 increased slightly over the record-breaking figures of 1910. The following table gives a comparison of the final figures of the United States Geological Survey for 1910 and the estimated output for 1911:

PRODUCTION OF PETROLEUM IN 1910 AND 1911

	1910 Barrels	1911 Barrels
Appalachian field..	31,985,515	28,000,000
Louisiana	6,841,395	10,000,000
Kansas and Okla..	53,157,386	56,000,000
California	73,010,560	81,000,000
Texas	8,899,266	9,000,000
Miscellaneous	35,661,926	33,000,000
	209,556,048	217,000,000

The total production for the United States is between 215,000,000 and 220,000,000 bbl. The gain in a single state—California—was greater than the net gain shown for the country as a whole.

The tendency to substitute oil for coal in many industrial establishments is growing rapidly. It is further encouraged by the possibilities of still greater economies by burning oil in internal-combustion engines. It has been adopted by the navy and its use increases on the railroads. Oil is being taken seriously.

Detroit Convention of Marine Engineers

The National Marine Engineers' Beneficial Association held its thirty-seventh annual convention at Detroit, Mich., during the week commencing Jan. 15. About 100 delegates were in attendance, representing associations from Seattle, Wash., to Portland, Maine, and from the Lakes to the Gulf.

The convention was called to order at the Tuller Hotel by National President William F. Yates at 10 o'clock on Monday morning. After a brief address, the committee on credentials was appointed by the president and the customary preliminary business was proceeded with. Mayor William B. Thompson then made the address of welcome. President Yates responded, thanking the mayor for his courtesy.

The social features included several theater parties and visits to the local plants, the main event being a smoker, which was attended by many of the prominent engineers of Detroit.

The following national officers were reëlected: William F. Yates, New York, president; David W. Miller, Seattle, first vice-president; George W. Bowen, Port Huron, second vice-president; Charles N. Vosburgh, New Orleans, third vice-president; George S. Grubb, Chicago, secretary; Albert L. Jones, Detroit, treasurer; William S. Brown, Edwin P. Groff, Frank J. Houghton, advisory board, and James J. Waters, trustee.

The supplymen's association connected with this convention elected F. E. Romsley, president; Charles Heitzman, vice-president; C. A. Wilhoft, secretary-treasurer.

The next annual meeting will be held at Charleston, S. C., next January.

I. O. E. Class in Plant Management

A series of discussions on plant management will be given by the Institute of Operating Engineers, 29 West Thirty-ninth St., New York City, on the first Tuesday of each month, at 8 p.m. The program is as follows:

Feb. 6. "Plant Records," Prof. W. D. Ennis, Polytechnic Institute.

March 5. "Employer and the Operating Engineer," F. R. Low, editor POWER.

April 2. "Systematic Inspection," H. E. Collins, secretary of the Institute.

May 7. "Fire-room Methods," E. G. Bailey, mechanical engineer, Boston, Mass.

June 4. "Handling Men," Willis Lawrence, chief operating engineer of the

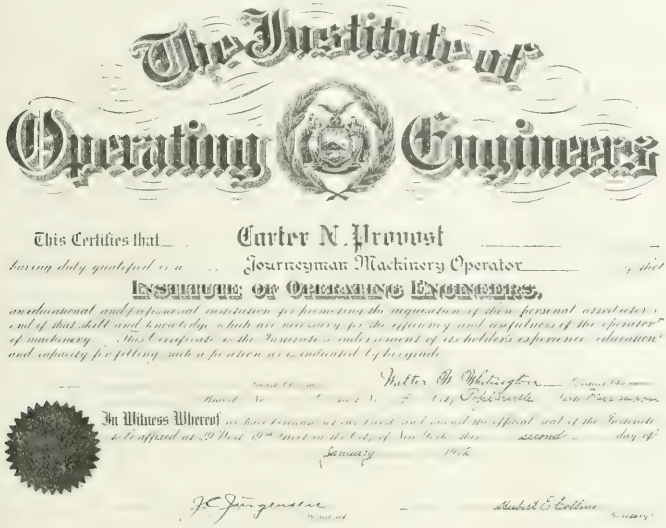
Interborough Rapid Transit, New York City.

July 2. "Essential Principles," J. C. Jurgensen, president of the Institute.

These discussions are open to the public.

The Institute Issues Its First Certificate

Carter N. Provost is the recipient of the first certificate issued by the Institute of Operating Engineers. The grade is that of journeyman machinery operator.



The applicant must be 21 years of age or over and must have served a regular apprenticeship to the machine, electrical or allied trades or have held positions either as machinery operator or fireman for at least 5 years. A reproduction of the certificate is presented herewith.

SOCIETY NOTES

Preparations are under way for the annual banquet of the Pittsburg Section, American Institute of Electrical Engineers, which will be held in the English room of the Fort Pitt Hotel, Saturday evening, Feb. 17. The banquet committee, of which K. C. Randall is chairman, announces that L. A. Osborne, vice-president of the Westinghouse Electric & Manufacturing Co., will act as toastmaster. The guest of honor and principal speaker will be Gano Dunn, of New York, president of the American Institute of Electrical Engineers. Other speakers will be Director A. A. Hamerschlag, of the Carnegie Technical Schools, and Henry E. Longwell, consulting engineer with the Westinghouse companies. The invitations include ladies. At least 350 plates will be laid.

NEW PUBLICATIONS

ELEMENTARY APPLIED MECHANICS. By Arthur Morley and William Inchley. Published by Longmans, Green & Co., London and New York. Pages, 282; numerous illustrations and tables; cloth. Price, $1 net.

The majority of writers upon this subject fall into the habit of employing calculus to a greater or less extent as a short cut to the end in view. As a matter of fact, however, this often has the effect of obscuring the line of reasoning to the man who has never studied calculus and very often to those who have. In the present case there is a marked absence of such treatment, only elementary algebra and trigonometry being employed.

The subject is handled in a logical manner and is fully amplified by numerous examples carefully selected with a view to their practicability. The chapters dealing with graphical statics and with power are especially instructive, and the use of curves and diagrams is clearly set forth.

Generally speaking, this is one of the best books upon the subject that we have seen, considered from the viewpoint of its adaptability to the needs of the engineer.

THE MECHANICAL WORLD ELECTRICAL POCKET BOOK FOR 1912. Published by Emmott & Co., Ltd., Manchester, Eng. Cloth; 224 pages, 4x6 in.; 80 illustrations; many tables. Price, 8½d., postpaid.

This year's edition contains new sections on verniers and micrometers, roller bearings, helical springs, and new material on other nonelectrical subjects, but the sections on dynamos and motors remain perfunctory and painfully inadequate in both quantity and quality. The mathematical tables remain, as heretofore, by far the most useful feature of the book.

The Mayville Specialty Manufacturing Co., Mayville, Wis., has just issued a 30-page handbook entitled "Horizontal Tubular Boiler Setting." The book treats briefly the work of installing return-tubular boilers and building their foundations and settings. In addition, it contains some useful hints on starting up a new boiler, laying a boiler up and on boiler operation in general. The book also describes the construction of and the manner of installing Monarch fire-door and back combustion-chamber arches. It should be of value and interest to every engineer and may be had for the asking by writing to the company.

BOOKS RECEIVED

HEAT AND THERMODYNAMICS. By F. M. Hartmann. McGraw-Hill Book Co., New York. Cloth; 346 pages, 6x9 in.; 72 illustrations; indexed. Price, $3.

A SHORT COURSE IN GRAPHIC STATICS. By William L. Cathcart and J. Irvin Chaffee. D. Van Nostrand Co., New York. Cloth; 183 pages, 4¾x7½ in.; 58 illustrations; indexed. Price, $1.50.

THE STEAM ENGINE AND TURBINE. By Prof. R. C. H. Heck. D. Van Nostrand Co., New York. Cloth; 631 pages, 5¾x9¼ in.; 402 illustrations; charts; tables; indexed. Price, $5.

MOTORS, SECONDARY BATTERIES, MEASURING INSTRUMENTS AND SWITCHGEAR. By S. Kenneth Broadfoot. D. Van Nostrand Co., New York. Cloth; 96 pages, 4x6½ in.; 16 illustrations; indexed. Price, 75 cents.

PERSONAL

Arthur D. Little, president and general manager of Arthur D. Little, Inc., chemists and engineers, Boston, Mass., was elected president of the American Chemical Society at its annual meeting at Washington. He was vice-president of the society and chairman of the Division of Industrial Chemists and Chemical Engineers.

Arthur H. Gill, associate professor of experimental engineering at the Pennsylvania State College, has resigned to accept a flattering offer in the industrial field. Prof. J. P. Calderwood has been assigned charge of the experimental laboratories in his place, and R. M. Pennock has assumed Professor Calderwood's classes in heat engineering.

Moments with the Ad. Editor

A. B. Gould of Cleveland, Ohio, is one of POWER'S subscribers who takes more than a passing interest in this page and in advertising.

He sent us a clipping from the *Cleveland Press* which shows the opinion of the Cleveland City purchasing agent of the salesmen he meets.

This is it:

"Leave Cigars Behind."

That is the sign at the entrance to the office of A. R. Callow, city purchasing agent. It's right where it catches the eye of a salesman entering the office.

"No, I haven't started an anti-smoking campaign," says Callow. "There are still a few salesmen who cling to the ancient practice of handing out cigars, and the sign is to head them off. I don't like the spirit in which a cigar is offered by a man with goods to sell.

"The wise, modern salesman doesn't hand out cigars. He is a business man who believes in his goods and who assumes that the purchasing agent is intelligent enough to wish to learn something about the merits of a good article.

"And by the way, you can take the words of 90 out of 100 salesmen relative to the goods they handle. They know a lie is soon found out, and that it is fatal to their chances of future sales."

The italics in that are ours and the emphasized portion points this lesson:

Probably no man is in a better position to judge the virtues or sins of a salesman than the purchasing agent of a large city. This one says that 90 per cent. of them tell the truth about their goods because, aside from any moral question, the lie would be fatal to their future chances.

Now, good advertising is nothing more nor less than *printed salesmanship.*

It, too, must be truthful or hurt its future chances beyond remedying.

The two-legged salesman *might* get away with the lie-stuff and hope that the memory of the purchasing agent would prove defective.

But the printed salesman is a recorded thing—it's down in black and white, preserved for all time, ready to be brought out against its perpetrator at any hour. The purchaser who has been buncoed has the *printed evidence.*

Do you imagine for a moment that any advertiser who is in business to stay will take a chance like that and pay real money for the white space in which to do it?

Not on your life!

He'd be a short-sighted crook, to put it mildly.

This matter of truth-telling in salesmanship and advertising is a development of business science.

The modern business man wants to know what will pay him and what won't. When he knows, as he does today, that truthful statements are the ones that win out in the long run he hitches his wagon to that star and stands back of the printed word and the verbal one.

So you, who are interested in the Selling Section of POWER, can read, believe in and buy from the advertisements with a full measure of confidence.

POWER

Vol. 35 NEW YORK, FEBRUARY 6, 1912 No. 6

EVER hear a man say, "I have so much work to do, I don't know where to begin"? If you have, you may have noticed that he stood around doing nothing all the time he was complaining instead of being busy doing some of his work. Several chances to one the man wasn't lazy. Probably he simply lacked system.

Ever hear a man say, "I haven't any time to read"? Without a doubt, that man has not been systematized.

When a man chronically "has too much to do," "has no time," "is too busy" to do this or attend to that, there is something the matter. And usually the trouble lies with the man himself.

There are some cases where a "job" actually is too big for one man, but they are rare. In the common or garden variety of overwork the trouble is simply that the "victim" is not living up to his capacity.

He needs a mental self over-hauling.

Probably his condition is due to gradual and natural growth in his duties on the one hand and lack of sufficient growth or improvement in his methods, on the other.

The one thing needful in such a case is to take about a half day off and carefully think out a "system" for putting his efforts to the best use. It is astonishing how much one can accomplish if a little time is spent in planning out the work ahead.

In some cases the thing to do is to delegate unimportant or routine work to a capable assistant. Too many men fritter away valuable time on work that might just as well be done by an understudy.

Wonderful things have been accomplished in certain manufacturing establishments by studying conditions and factors and then laying out the work both of the apparatus and the operatives so that each could work to best advantage. In many cases the results have been advantageous to both the employer and the employee.

This is called efficiency engineering.

Now, efficiency engineering can be applied to the individual and his work just as well as to an entire establishment. Boiled down and shorn of all its frills and refinements, efficiency engineering means simply the use of common sense.

Bear in mind that time is money. In justice to yourself don't squander it upon tasks that are not worth the price. First, get a rational point of view of the worth of your time; then, lay out a plan for spending it to the best advantage; and finally, stick to it!

Various Types of Steam Meters

By Prof. G. F. Gebhardt

General classification of steam flow meters and description of the principal types.

In the present article, those meters are considered which fall in the velocity class; those in the throttling class will be treated in a second installment.

The weight of fluid flowing through an opening at any instant may be calculated by the equation

$$W = A\,v\,V \qquad (1)$$

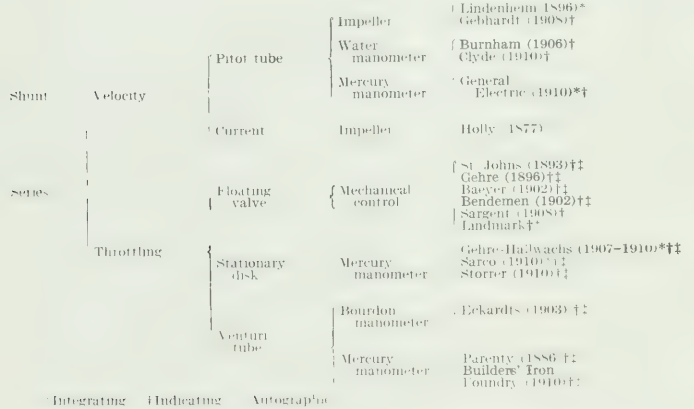
in which

W = Weight in pounds per second;
A = Cross-sectional area in square feet;
y = Density of the fluid in pounds per cubic foot;
V = Velocity of flow in feet per second.

All steam meters for indicating or recording the weight of steam flowing through a pipe are based upon the law expressed in equation (1). Thus, for steam of constant density the opening through which it flows may be made constant and the variation in velocity will be an indication of the rate of discharge; or the velocity may be held constant and a variation in the amount of opening will be an indication of the weight discharged.

Unfortunately, the density of steam is seldom constant for any appreciable length of time under commercial conditions of operation, and herein lies the inherent defect of all steam meters which depend for their operation upon a variation in the area of efflux or a variation in velocity. The density of steam is a function of its pressure and quality and any variation in either will affect the weight of discharge as determined from equation (1). Pressure variation may be automatically compensated for, but corrections for quality must be made in each specific case.

The different means adopted for transmitting this area and velocity variation to the indicating or recording devices overlap to such an extent as to render a classification of steam meters very unsatisfactory. The chart is offered as a guide in grouping the most commonly



From this chart it will be seen that all meters may be grouped into two general classes, which, for want of more suitable names, may be designated as shunt meters and series meters. Owing to lack of space only those of the former class will be described in this article, and those of the latter class will be taken up in a succeeding article. The series meter is an integral part of the piping and the entire mass of fluid to be measured passes through the apparatus. It is not portable and cannot be readily applied to pipes of different sizes. In the shunt meter only a small portion of the fluid to be measured is diverted through the apparatus, and the pipe line need not be disconnected for its installation. One instrument suitably calibrated may answer for any size of pipe.

Both series and shunt meters may be grouped into two classes, depending, first, upon whether the natural velocity existing in the conduit is used to operate the indicating mechanism or, second, whether an artificial pressure drop affords the means of actuating the mechanism. The first type may be classified as "velocity" meters and the latter as "throttling" meters.

Velocity meters may be subdivided into two groups: those in which the current of steam impinges directly against the vane of an impeller and those in which the pressure due to velocity actuates the indicating or recording mechanism.

Holly Steam Meter

One of the earliest steam meters recorded was constructed in 1877 by Birdsill Holly, a section through which is shown in Fig. 1. The upper impeller is placed in the path of the steam and its speed of rotation is a measure of the weight of steam flowing. The lower impeller is submerged with a view of decreasing the speed of the rotor. The results were never satisfactory as the inertia of the rotating members caused the vanes to run ahead or lag behind the stream and the windage and eddy losses were variable.

Lindenheim Steam Meter

The Lindenheim meter, Fig. 2, is a marked improvement over the Holly in

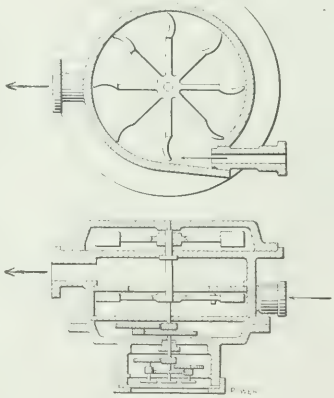


Fig. 1. Holly Steam Meter

that it compensates for pressure variation and does not require the entire mass of fluid to flow through the apparatus. It consists of an impeller inclosed in a steam-tight casing attached to the main pipe as indicated. The rotation of the impeller is transmitted to the counter through the agency of a variable speed cone, C, the position of which is shifted by a steam-actuated diaphragm, and this movement is transmitted to the cone, thus compensating for the pressure change. This instrument, like the Holly, was never a commercial success on account of friction of the stuffing-boxes and gearing and the losses due to windage of the impeller and eddies.

Gebhardt Steam Meter

During the past few years the writer has constructed a number of velocity meters which have overcome some of the defects of the Lindenheim device. Referring to Fig. 3, a thin, smooth aluminum

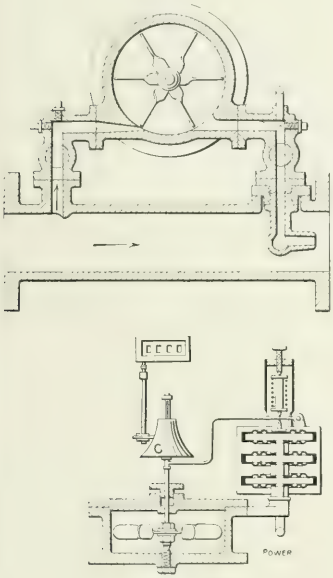


Fig. 2. Lindenheim Steam Meter

ring *A*, with a permanent steel magnet *N* (inlaid as indicated), is supported on pivot bearings within a steam-tight casing *O*. A small jet of steam impinges upon the periphery of the disk and effects rotation. The motion of the disk is imparted by the magnet *N* to magnet *N'*, outside the casing. By this construction windage and eddy losses have been appreciably lowered, inertia has been gradually reduced and stuffing-box friction has been entirely eliminated. Tests of these instruments when new gave results agreeing within 10 per cent. of condenser measurements for continuous flow and for velocities between 25 and 50 ft. per second, but the error increased with the higher velocities. Difficulty with the bearings rendered them inoperative after a few days' trial on account of the extremely high speed of rotation. No attempt was made to automatically compensate for changes in pressure or quality of the steam.

Fig. 4 shows a modification of the instrument just described, in that the wheel does not revolve but is constrained to move through the arc of a circle by the spiral spring *G*. The device is purely indicating. The impulse of the stream increases with the velocity and deflects the wheel *A* through a greater angle, the degree of deflection being a measure of the weight flowing through the main pipe. By means of suitably calibrated charts the instrument may be made to give fairly consistent results for a uniform flow and constant pressure and quality of steam. For intermittent flow the results are extremely erratic.

In point of compactness, simplicity, ease of application and the integrating feature of the mechanism, the impeller type of velocity meter fulfills the requirements of the ideal meter, but it is probable that its inherent limitations will prevent it from ever becoming a commercially successful instrument.

Burnham Steam Meter

The Pitot tube is the basis for the operation of a number of commercially successful steam meters of the velocity type. Fig. 5 shows a section through a Burnham meter, illustrating one of the simplest methods yet devised for indicating the rate of flow through a pipe. *A* and *C* are two ordinary gage-cocks and *G* is a common gage-glass; *C* being connected with the static nozzle *S*, and *A* with the dynamic tube *D*. The height of water *H* is proportional to the square of the velocity of steam flowing through pipe *P* and automatically adjusts itself to the variations in velocity; thus, for decreasing velocities, the water in glass *G* discharges through *D* until the water column *H* balances the velocity pressure in pipe *P*, and for increasing velocities, condensation from the upper part of the instrument accumulates and the water column *H* rises until a balance is effected for the higher velocities.

This simple device in connection with a calibrated scale gives readings within 5 per cent. of condenser measurements for continuous flow and constant pressure and quality of steam (for velocity pressures corresponding to 1½ in. of water or more). For a considerable variation in pressure and quality or for marked changes in the rate of flow, the instrument is not reliable. Its sensitiveness is greater at high velocities since the height of the water column in the gage-glass increases with the square of the velocity of the steam in the main pipe. For interrupted flow, as when connected to a high-speed engine, the water column may be made to closely approximate the mean velocity by suitably throttling the gage-cocks.

Fig. 6 shows an application of the same principle with only one connection to the main pipe.

The limitations of the instrument just described which materially affect the accuracy at low velocities are due, first, to fluctuation in the height of the water at the end of tube *D*, due to surface tension; second, to variations in the density of the water column in the gage-glass *G*; third, to capillarity in the gage-glass *G*; fourth, to a sudden increase in velocity, tending to "blow out" the water column, and, fifth, to eddies in pipe *P*. Notwithstanding these limitations the instrument is sufficiently accurate for many purposes when a purely indicating device is desired.

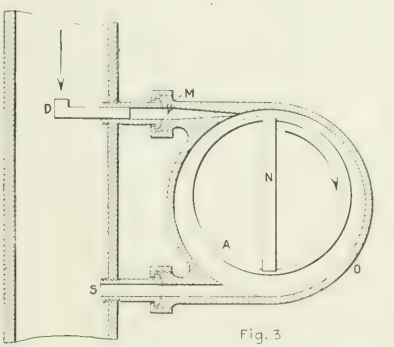


Fig. 3

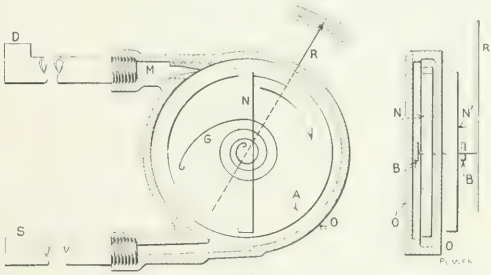


Fig. 4

Gebhardt's Steam Meter

Fig. 7 shows a modification of the Burnham meter in which the defects of the single gage-glass device are eliminated. The error due to the variation in water level at the end of the dynamic nozzle is entirely dispensed with by making the tube a "dry" tube; that is, water of condensation is not returned through

the dynamic nozzle. The temperature of the water in the gage-glass is practically constant, all condensation from the static end being discharged through the drain *F* to the chamber below, and all water carried over by the dynamic end being discharged into pipe *P* directly to the overflow *G*. The area and volume of the chamber *M* are so large compared with those of the glass *W* that sudden variations in flow do not materially affect the level of water in *M* and cannot blow the water out of *W*. The only defect in the instrument is the error due to capillarity in the glass *W*, which amounts to but 0.05 in. for a ¾-in. tube.

The operation is as follows: Velocity pressure is transmitted through tube *D* and opening *O*, into the body of the chamber *M*. This pressure, acting on the surface of the condensed water in the chamber, forces the water into the glass *W* until a balance is effected. Condensation is discharged continuously through pipe *P* and the water seal *U* of the main pipe. Tests of this meter have given results agreeing within 2 per cent. of the condenser measurements for continuous flow for all velocities ranging from the equivalent of a 1-in. to a 10-in. water column. No provision is made for automatic correction of the pressure and quality variation.

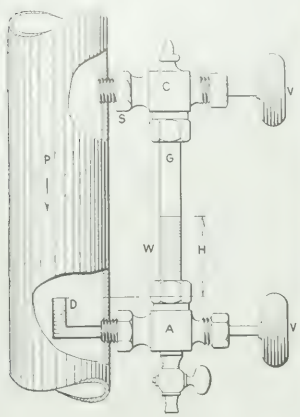


Fig. 5

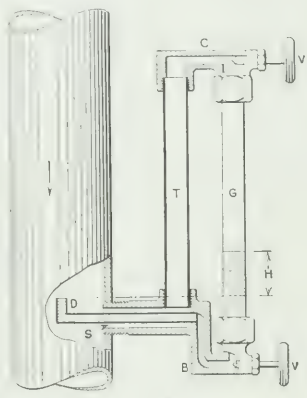


Fig. 6

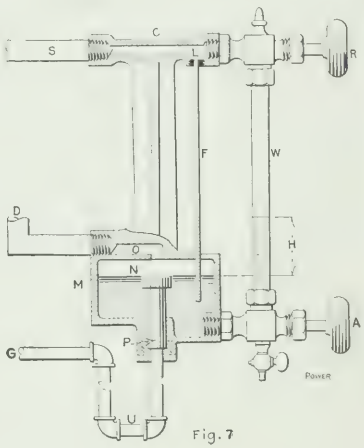


Fig. 7

FORMS OF BURNHAM STEAM METER

CLYDE STEAM METER

Fig. 8 shows a commercial form of the Burnham meter as constructed by the Clyde Machine Works, of Chicago. It differs from the one described in Fig. 6 only by the addition of the tube *A*, the function of which is to insure static pressure in chamber *C*. The chart is graduated for a considerable range in pressure and quality. It is a purely indicating device and readings must be taken frequently to obtain average results.

The relation between the height of the water column and the velocity of the steam in the main pipe at the entrance to the dynamic tube in the Burnham type of meter may be determined from the well known equation

$$V = c\sqrt{2gh} \qquad (2)$$

in which

V = Maximum velocity of flow in feet per second;

K = Coefficient determined by experiment;

h = Height of water column in inches;

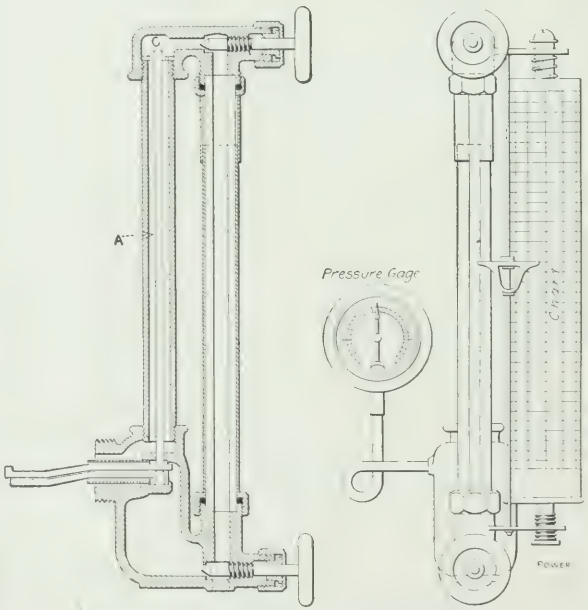


FIG. 8. COMMERCIAL FORM OF BURNHAM METER

c = Coefficient determined by experiment;

g = Acceleration due to gravity = 32.2;

H = Height of a column of steam equal in weight to the water column H.

This equation may be expressed as

$$V = K\sqrt{h - \frac{dw}{ds}} \qquad (3)$$

in which

dw = Density of water in gage-glass in pounds per cubic foot;

ds = Density of steam in the main pipe.

By combining equations (1) and (2)

the weight of steam flowing is readily calculated. (See *Transactions*, A. S. M. E., Vol. 31, p. 603.)

General Electric Steam Meter

The General Electric Co. has recently placed on the market a number of steam meters of the Pitot-tube type in which a mercury column is used to measure the velocity pressure. The principle involved is an old one, but this company is the first to exploit it successfully from a commercial standpoint. Three styles are manufactured, (1) type I, form D, in which the velocity pressure is measured directly by means of a U-tube manometer; (2) type I, form F, in which the variation in the height of the mercury is transmitted to an indicating dial through the agency of floats and pulleys, and (3) type R, form D, in which the variation in the weight of the mercury column actuates a recording mechanism by means of a series of compound levers.

The principle of the simple indicating device is illustrated in Fig. 9, in which *S* is the static nozzle at right angles to and *D* the dynamic nozzle facing the current; *U* is an ordinary U-tube manometer partially filled with mercury. When there is no flow the surface of the mercury in the columns *N* and *W* will be on the same level and the upper portions will be filled with condensed vapor. When there is a flow, the mercury will be depressed as indicated and the difference *H* in the heights of the mercury columns will be a measure of the velocity of flow at the point in the pipe where the dynamic tube is placed.

This velocity may be expressed by substituting the proper values in equation (2), thus

$$V = K\sqrt{h - \frac{d\,m}{d\,s}} \qquad (4)$$

in which

dm = Density of the mercury in pounds per cubic foot (other notations as in equation (3).

A comparison of equations (3) and (4) will show that the mercury manometer is less sensitive than the water manometer by an amount equivalent to $\sqrt{\frac{d\,m}{d\,w}}$ or approximately 3.7. The variable height of the water column above the mercury is usually included in the value of the coefficient *K*.

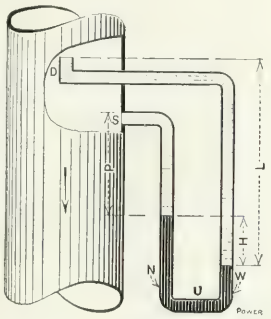


Fig. 9. Pitot Tube with Mercury Manometer

The General Electric indicating flow meter, shown in Fig. 10, differs from the simple device just described in that a simple nozzle plug, shown in detail in Fig. 11, is used in place of the ordinary static and dynamic nozzles. Referring to Fig. 11, *TT* are the static openings, or "trailing set," and *LL* the dynamic openings or "leading set." The plug is screwed into the pipe with the "leading set" directly facing the current and the connections to the manometer are made through the openings *T'* and *L'*. The weight of steam flowing may be obtained directly from the height of the mercury column *H*, Fig. 10, by means of suitable charts based upon experiments. Adjustment for variations in pressure, quality and pipe diameter are made by setting the chart cylinder *C* in accordance with the graduated scales at the bottom of the instrument.

For general purposes a single revolving chart is furnished, the readings of which, multiplied by the area of the pipe, give the weight of steam flowing. For low velocities the difference in the heights of the mercury columns, if vertical, is so small as to lead to serious error; hence provision is made for this by inclining the manometer as indicated in Fig. 12. With this the actual head of mercury due to the velocity is *H*, but the difference in the lengths of the columns is *D*. The indication on the chart corresponding to the height of the mercury in the glass *T''*, multiplied by a constant depending upon the inclination of the chart, is the rate of flow in pounds per hour per square inch of the pipe cross-section.

The accuracy of this meter depends entirely upon the refinement of adjustment and the extent of error in reading the height of the mercury column. If correctly set, an error in reading of $\frac{1}{16}$ in. for a velocity corresponding to a vertical column ½ in. high would be 12½ per cent., whereas the same error referred to a vertical column 6¼ in. high would be but 1 per cent. Tests of this instrument, conducted at the Armour Institute of Technology, gave readings for continuous flow agreeing within 1 to 8 per cent. of condenser measurements, depending upon the rate of flow. For interrupted flow the departure from condenser readings was more marked. This meter is portable, simple in construction and readily applied to any pipe by inserting the nozzle plug at the required point, although considerable care is necessary in setting it up and in making the necessary adjustments for pipe diameter, steam pressure and quality.

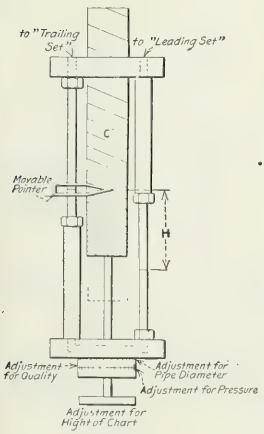


Fig. 10

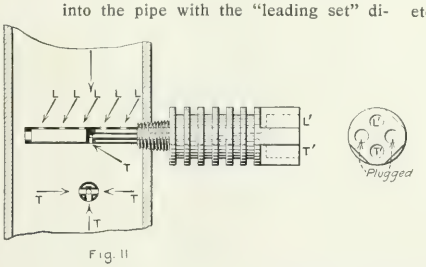


Fig. 11

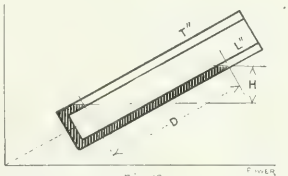


Fig. 12

General Electric Indicating Flow Type Meter, Nozzle Plug and Inclined Mercury Manometer

Fig. 13 gives the general details of the type I, form F, indicating flow meter. It differs from the one just described in that the variation in height of the mercury column is transmitted through a float and pulleys to two bar magnets, one within the casing and the other without. The indicating needle is fastened to the outer magnet and revolves in harmony with the variation in height of the mercury column. A movable rack fitted with a pointer, and operated by graduated cylinders for pipe-diameter,

pressure and quality adjustments, indicates the portion of the circular chart from which the needle readings are to be taken; these adjustments must be made by hand. This instrument is fully as accurate as the one previously described, but it is much more delicate and is more easily disarranged. Connection

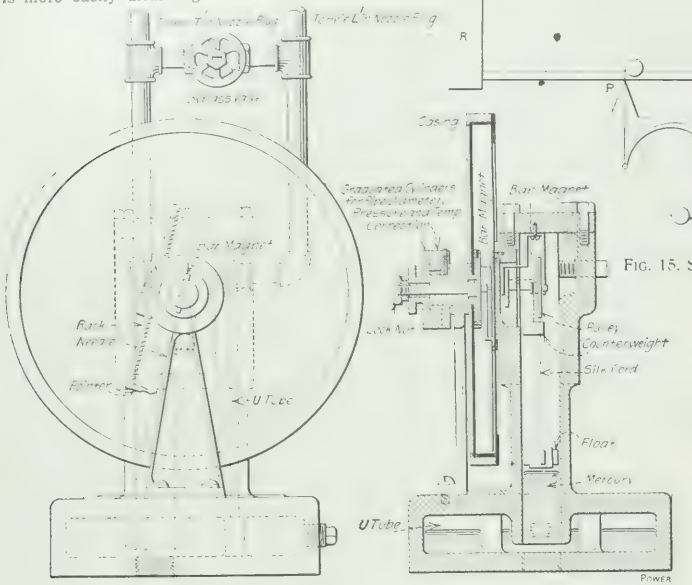


FIG. 13. GENERAL ELECTRIC TYPE I, FORM F METER

is made with the main steam pipe by nozzle plugs which are interchangeable with either instrument.

The autographic instrument, Fig. 14, is finding much favor with engineers and is being rapidly adopted by the large power plants. Its operation is shown diagrammatically in Fig. 15. Two cylindrical mercury cups, *R* and *R'*, constituting the legs of a U-tube mercury manometer are pivoted on a knife-edge *P*, and are connected to the nozzle plug by the flexible tubes *A* and *A'*. The instrument may be placed at any point below the level of the nozzle plug, one instrument being sufficient for a number of nozzles. When there is no flow the mercury in the two wells is at the same level and the system is in perfect balance. When there is a flow the velocity pressure causes the mercury to flow from *R* to *R'* and the latter is lowered, carrying with it the recording pin *C*. The vertical distance on the chart between *O* and *C* is a measure of the weight of steam flowing. (This system of mercury wells was used as early as 1886 in a steam meter designed by Parenty.

Pressure variation is automatically compensated for by the sliding weight *W*, the position of which relative to the knife-edge is effected by the Bourdon tube *G;* thus for increasing pressures the gage tube tends to straighten out and lower the weight, thereby increasing the leverage of the well *R'*. Adjustment for quality is made by shifting the position of the weight *W* by hand. Thirty of these meters are in use at the Argo power plant of the Corn Products Refining Co. and, according to tests made by the engineering staff, are accurate within 2 per cent. of condenser measurements for continuous flow.

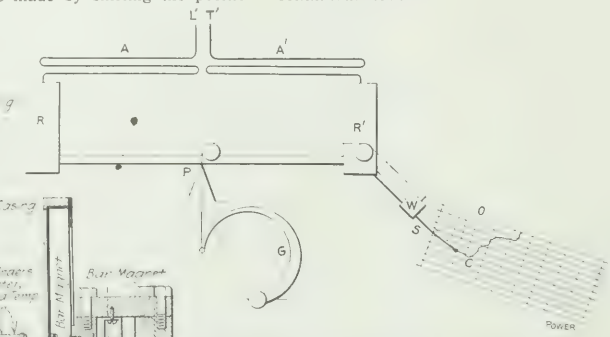


FIG. 15. SHOWING PRINCIPLES OF GENERAL ELECTRIC RECORDING STEAM GAGE

The writer's experience with this style of meter has been very satisfactory for continuous flow, but the results were not consistent for interrupted flow when connected with a reciprocating pump or engine, the chief objection being that the charts must be integrated in order to ascertain the total flow for any given period of time. The ordinates on the chart are not directly proportional to the weight of steam flowing; hence the diagram cannot be integrated in the usual manner with an ordinary planimeter. The General Electric Co. furnishes a planimeter which is designed to compensate for the variation in the value of the vertical coördinates so that the average flow per unit of time can be determined.

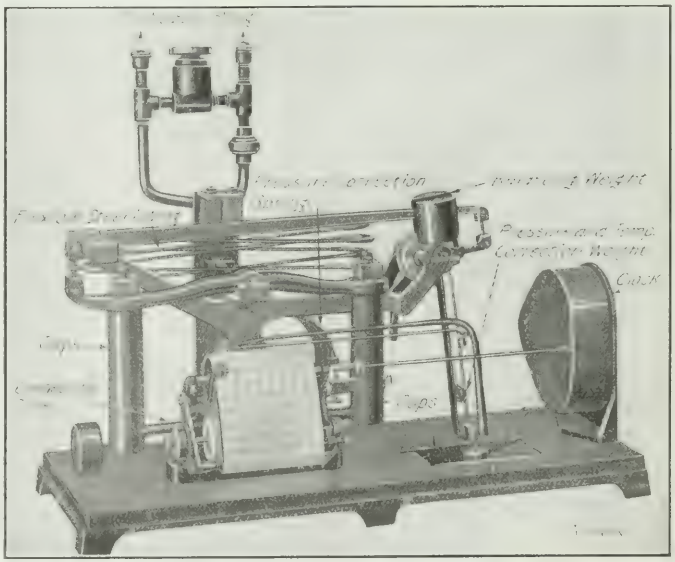


FIG. 14. GENERAL ELECTRIC RECORDING STEAM METER

Oil Burning with Different Settings

Results of a series of tests carried out on a horizontal return-tubular boiler to determine the relative economy of different furnaces and the effect of variation in the draft when burning oil.

A recent bulletin of the Lousiana State University and A. & M. College contains the results of some interesting tests made by Prof. Kerr and H. A. Nadler, of that university, upon different types of oil-burning furnaces. The tests were conducted upon a 6x18-ft. horizontal return-tubular boiler at the Smithfield sugar factory during the past sugar-drying season. The draft was supplied by a single stack which served a battery of three boilers, one of which was used in making the tests. With the exception of the last two, all the tests were made with a Higgins burner.

Setting No. 1

Reference to Fig. 1 will show that the setting was arranged so that the air for combustion could be supplied to the under side of the grate through a long duct from the back end of the boiler setting. This duct, behind the bridge-wall, was covered over with brick loosely thrown in, the object being to preheat the air before it reached the burner. The end of this duct was arranged so that the amount of opening could be controlled or closed. In this setting the draft-doors were tightly closed by means of brick and mortar. The fire-doors were closed in the same manner, excepting for two openings of about 2½x4½ in. each, which were used as peep-holes, but which, when the boiler was in operation, were entirely closed by the insertion of bricks. Thus the entire front of the furnace was closed, all the air admitted coming from the rear of the setting through the brick duct. The air thus delivered to the under side of the grate was admitted to the furnace above through an opening 4 in. wide between the front of the grate and the front of the furnace wall, the grate, with this exception, being solid. The grate-bars were covered with two layers of firebrick laid flat. In this way there was no possibility of air flowing into the furnace except through the 4-in. opening at the front. On this flat surface bricks were thrown in loose so as to give a gradual slope from near the front of the grate up to the top of the bridge-wall. With the tests made on this setting, as with all the others, the draft was regulated by means of a damper in the flue leading to the stack.

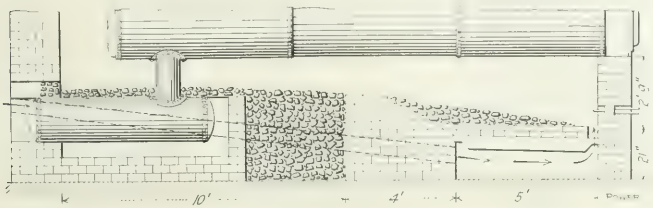


Fig. 1. Setting No. 1

Reference to tests Nos. 1 to 8 inclusive, in the accompanying table, shows that the lowest economy (No. 7) occurred with the damper wide open and with only 75.3 per cent. of the rated load. The next lowest economy occurred in test No. 3, with normal load and the damper closed until the draft in the flue was reduced to .092 in. On the other hand, the best economy was that shown in test No. 5 where there was a slight overload and medium draft. In tests Nos. 3 and 6 where the evaporation was low, the damper was closed so far as to fill the setting with smoky, rolling flames, although no smoke appeared from the top of the stack.

The fact most clearly shown by these tests is that the economy is reduced by too high or too low draft, depending upon the load.

Setting No. 2

The most common method is to admit all of the air in oil burning at the front of the furnace in such a manner that the air enters in currents practically parallel to the current of fuel issuing from the burner. As the atomization and gasification of the fuel are incomplete immediately after its issue from the burner, it would seem that admission of air toward the back end of the furnace should be advantageous, especially if it could be injected across the current of gases so as to facilitate mixture of gases and air. With this in view, setting No. 2, as shown in Fig. 2, was arranged so as to admit air through the furnace floor just in front of the bridge-wall. For this purpose all of the loose brick was removed, leaving the grate covered with a smooth, flat layer of firebrick although just in front of the bridge-wall these bricks were left sufficiently far apart to provide seven ½x8-in. holes. The 4-in. opening between the ashpit and the furnace was provided as in setting No. 1, so that air entered at this place as well as through the grate at the back. In other respects, the setting was the same as No. 1, the air being preheated by its passage from the rear of the setting. Upon starting the burner with the arrangement just described it was found that too much air entered at the bridge-wall and that the flames were directed by the bridge-wall against one spot on the bottom of the boiler shell. To remedy this the holes in the grate at the back were gradually closed during the preliminary runs until the only air which entered at this point leaked past bricks which were laid flat over the holes. The result was that the quantity of air entering at this point was comparatively small, though the flames were still thrown almost perpendicularly

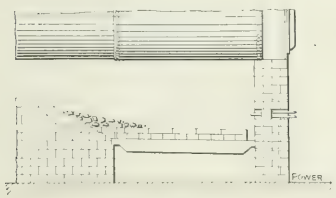


Fig. 2. Setting No. 2

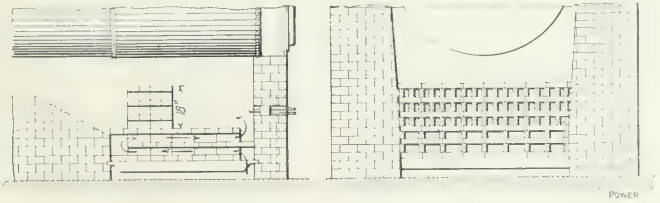


Fig. 3. Setting No. 3

against the boiler shell. This latter was remedied by throwing in a small quantity of loose brick.

However, on account of the difficulty of securing a satisfactory distribution of the flame throughout the setting and the heating surface, only one test was made.

Setting No. 3

In this setting arrangement was made for preheating the air by passing it back and forth through firebrick passages directly under the furnace (see Fig. 3). The grate-bars were lowered almost to the floor of the ashpit and a network of brick was built up by placing one upon another without any mortar so as to give the desired path to the gases as indicated.

In order to diffuse the fuel and mix the air and the gases, a checkerwork wall was built above the floor of the furnace. The air ducts from the rear of the setting were closed and all the air entered through an opening of practically 1 sq.ft. in the ashpit door.

Test No. 10 was thrown out on account of an error in the feed-water measurement. Owing to conditions at the factory it was impossible to carry the full load while running with this setting. Hence, as underloading reduces the efficiency, it may be assumed that the evaporation per pound of oil would have been better for this setting under normal load. Notwithstanding this, the results compare very favorably with those in setting No. 1.

Setting No. 4

In this setting, shown in Fig. 4, the checkerwork used for diffusing the gases in setting No. 3 was replaced by loose bricks thrown in so as to slope gradually from near the front of the grate to the top of the bridge-wall. As with setting No. 3, the air was preheated by its passage back and forth under the furnace, all air being admitted from the front.

Test No. 14, with this setting, was made with an air supply adjusted in the light of former tests, to give the best possible results. The lower evaporation per pound of oil, 14.88, was, therefore, somewhat unexpected, especially in view of the favorable conditions as regards load and excess air. Test No. 15, however, under practically the same conditions, gave an evaporation of 15.38 lb. It should be noted that the boiler tubes were blown out just prior to this last test, which, no doubt, accounts in part for the increased efficiency.

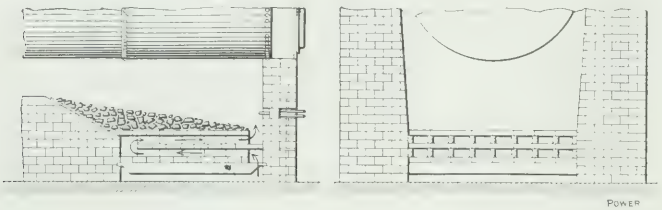


Fig. 4. Setting No. 4

Setting No. 5

This setting, shown in Fig. 5, is the same as setting No. 4 as far as that part of the furnace in front of the bridge-wall is concerned. In all the previous settings, however, that part of the combustion space back of the bridge-wall was filled with firebrick to the level of the top of the bridge-wall. With the idea of investigating the value of this space for combustion, the loose bricks were removed to a depth of about 15 in., although the brickwork around the muddrum prevented this enlargement all the way back. With the idea also that some air admitted back of the bridge-wall would aid in better combustion, a 4-in. pipe with a number of 1-in. holes in it was inserted through a hole in the side wall of the furnace just back of the bridge-wall. The holes were located so that the air entering would be divided upward at right angles to the current of gases. As in the previous settings, the air entering at the grate came from the front of the furnace, although the opening in the ashpit door was nearly closed.

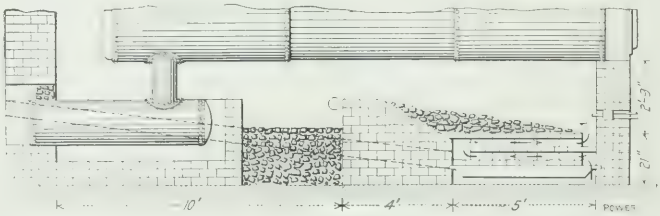


Fig. 5. Setting No. 5

Aside from tests 22 and 23, which were made with burners of a size insufficient to carry the load, the lowest evaporation was that in test 17. In this test the damper was closed to such a point that the furnace was filled with a rolling flame, a condition accompanied by a low efficiency in the other settings. Test 19 was thrown out on account of leakage in the feed-water line. The damper was closed too much in test 16, although not quite so much as in 17. The remaining tests showed very good results. It will be noted that the excess air was lower in these tests than in most of the others, which may be due to the admission of air through the pipe at the rear of the bridge-wall and to the enlargement of the combustion space back of the bridge-wall.

Conclusions

The tests showed that the amount of steam used in atomizing depends largely upon the operation of the burner, a white flame being usually accompanied by a small consumption of steam for atomizing and a transparent red or orange flame by a large quantity of steam. The average percentage of steam used for atomizing (about 4.38) shows fairly good work, although it is not by any means the best, as 2.5 to 3 per cent. can be obtained under the proper conditions. Further inspection of this column shows that the percentage of steam used for this purpose decreases with the load.

The increase in economy due to proper draft regulation is plainly shown by the results of the tests, although certain variable conditions, such as load, made the results due to changing the draft less regular than they otherwise would have been. The relation between draft and load is shown by the curves in Fig.

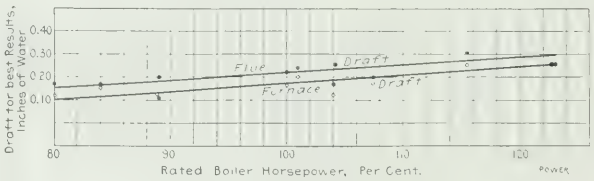


Fig. 6. Effect of Draft on Horsepower

6. In this it will be noted that the average distance between the curves for furnace draft and flue draft represents about .04 in. of water. This difference represents the friction of the gases in the boiler tubes and passages. It might have been expected that this difference would have been greater as the load increased, due to increased volume, and therefore a greater velocity of the gases. However, in general, there was less excess air at the greater loads.

With the flue damper wide open, the flame in the furnace moved at a high velocity with a tendency to break up and disappear at or near the bridge-wall, the color being rather light. Upon gradually closing the flue damper the velocity of the flame could be seen to decrease, the flame extending farther and farther toward the rear of the setting and becoming denser and redder. By continuing the gradual closing of the damper a point was reached where the velocity of the flame was very low and the flame would roll, and the furnace setting would be entirely filled with a dense and generally smoky-looking flame, this without smoke at the top of the stack. The tests showed that this latter appearance is an indication of a condition very near that which gives the best efficiency and that by setting the damper at a position just short of this rolling action of the flame the best effec. is obtained.

Since the best boiler efficiency is dependent not only upon proper air supply but also upon proper loading, it is best, as far as possible, to take care of the variations in load with as few boilers as possible. In other words, instead of slightly reducing the fuel supply to all of the burners when the load is reduced, it is better to make the reduction with one or two boilers and not change the others.

World's Coal Production

The following figures show, according to the United States Geological Survey, the coal production of the principal countries of the world in 1910, except those for which only 1909 figures are available:

United States	501,596,378
Great Britain	296,007,699
Germany	245,043,120
Austria-Hungary (1909)	54,573,788
France	42,516,232
Belgium	26,374,986
Russia and Finland	24,967,095
Japan (1909)	16,505,418
Canada	12,796,512
China (1909)	13,227,600
India (1909)	13,294,528
New South Wales (1909)	7,862,264
Spain (1909)	4,546,713
Transvaal	4,446,477
Natal	2,572,012
New Zealand (1909)	2,140,597
Mexico (1909)	1,432,990
Holland (1909)	1,235,515
Queensland and Victoria	1,119,708
Italy (1909)	611,857
Sweden (1909)	272,056
Cape Colony (1909)	103,519
Tasmania (1909)	93,845
Other countries	5,236,903
Total	1,278,577,812
Percentage of the United States	39.2

PRINCIPAL RESULTS FROM TESTS WITH DIFFERENT SETTINGS

Test Number	Conditions of Test	Steam Pressure, Gage	Flue Temperature Deg.	Draft in Flue, Inches of Water	Draft in Furnace, Inches of Water	Per Cent. of Rated H.P. Developed	Evaporation from and at 212 deg. per Lb. of Oil	Steam for Atomizing, Per Cent. of Total	Excess Air, Per Cent.	Efficiency of Boiler, Per Cent.	Efficiency of Boiler and Furnace, Per Cent.
	SETTING NO. 1										
1	Steady load; no smoke	74	403	0.117	0.089	81.5	14.35	2.89	107	71.6	69 5
2	Heavy long flame; damper wide open; ash-pit doors closed; air from back of setting	81	402	0.224	0.164	102	15.41	5.98	97.5	76.6	72 3
3	Smoky rolling flame; no smoke from stack, air from back of setting; steam valve on burner wide open	70.9	449	0.092	0.102	99.1	14.06	6.15	65.9	70.3	65 2
4	Long heavy rolling flame; damper wide open; air supply from rear, high velocity of gases	76.2	466	0.320	0.251	117.6	15.32	3.85	124	76.3	73 5
5	Whitish yellow flame at front ending with blue at rear. Draft less than in No. 4; steady load; as little steam as possible used in burner	88.2	454	0.175	0.132	106	16.1	6.28	....	80.1	75 2
6	Fire rolling and completely filling combustion chamber	88.4	463	0.162	0.132	110	14.41	4.44	53.8	71.8	68 7
7	Air ducts from rear closed; air supply from opening in ashpit door; short white flame; damper wide open	88.5	461	0.282	0.227	75.3	13.2	5.19	184.8	65.6	67 5
8	Conditions similar to No. 7, with damper opening slightly changed	85.3	476	0.11	0.11	89.3	15.75	5.25	69.1	78.4	74 4
Average		81.56	446	0.185	0.151	97.6	14.83	5.06	96.7	73.8	70.8
	SETTING NO. 2										
9		81	483	0.147	0.126	99	14.46	4.85	64.8	72.1	68.5
	SETTING NO. 3										
11	Medium draft, clear fire, flame slightly blue and ending just back of bridge-wall	80.7	489	0.235	0.149	86.2	14.45	6.57	121.2	72.1	67.2
12	Draft less than No. 11 and short, transparent flame	85.3	476	0.171	0.12	80	15.56	5.89	114.8	77 5	73.0
13	Boiler washed out previous to this test	81.9	460	0.20	0.13	89	15.26	5.0	106.2	76	77 2
Average		82.6	475	0.20	0.13	85.1	15.09	5.82	114.1	75.2	79.8
	SETTING NO. 4										
14	Transparent white flame ending just back of bridge-wall; firebrick very hot	84.3	462	0.175	0.158	104	14.88	3.67	89.3	74.25	71.5
15	Tubes blown just before starting test; flame white and opaque; draft higher than in No. 14	86.75	462	0.222	0.202	103	15.38	5.26	89 3	76.6	72.7
Average		85.52	462	0.187	0.180	103.5	15.13	4.46	89 3	75.42	72.1
	SETTING NO. 5										
16	During first hour, clear bluish rolling flame; later, shorter flame due to increased air supply	85.8	417	0.159	0.155	84	15.18	4.41	65	75.6	72.4
17	Load steady; damper closed; heavy bluish flame at front, clear at back	86.9	454	0.184	0.182	109.5	14.70	2 25	37	73.2	71 5
18	Same as No. 17 except more draft; steam valve wide open	80.8	479	0.253	0.258	123	15.56	3.2	55.5	77.7	75.0
20	Long white opaque flame; damper such that further closure would cause flame to enter tubes	88.8	456	0.197	0.170	109.5	16 05	2.37	75.5	80.0	78 2
21	Heavy draft	85.5	472	0 345	0.262	106.2	15.31	3.21	88	76.4	74.0
Average		82.1	456	0.227	0.205	106.4	15.35	3.09	70.2	76.6	74.2
22	Von Phul burner used at full capacity; white flame	83.1	432	0.210	0.181	89.8	14.05	3.00	108.5	70.2	68 0
23	Home-made burner	84.7	419	0.175	0.145	69.4	14.22	3.19	.....	71.0	68 8

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

Tom Hunter continues his narrative on hoisting engines and tells why overwinding accidents occur. He explains a device which he made to prevent confusion of signals and so avoid accidents.

Thanksgiving morning dawned cold and dull, and the air was occasionally filled with flurries of snow from off the mountains which surrounded the town. I saw but little of Hunter during the day, but after the six-o'clock dinner we selected comfortable seats and after lighting our cigars, he said:

"I am at a loss just what to say or where to begin. So much has happened during my career that, taking it all in all, it would require a good many evenings to tell of my experiences."

"Tell me of the most thrilling you have had," I suggested, as I leaned back in my seat.

A Thrilling Experience

"The most thrilling experience, I think, was the one I mentioned last night. It occurred years ago, when I was a young man, and the lives at stake were those of a dozen miners who were being hoisted to the surface after their day's work was done. By chance, it was on a Thanksgiving eve, and possibly the thoughts of the holiday caused me to allow my mind to wander to other things besides my work.

"I had been hoisting coal from the bottom level when I got the signal to stop at the second level, which was down about three hundred feet, while the lower level was a trifle over a thousand feet deep. A hoisting engineer is most likely to make a mistake when, having worked at one level, he changes the drum and hoists from another. He gets in the habit of gaging the time it will take the car to run up and does not watch the indicator as closely as he should.

"The engine room was built with a window in the wall just back of the double drum so that it was possible to see the shaft head, and this undoubtedly saved the lives of those men. I got the signal to change from the bottom level to the second and then came the signal to hoist. It was then that I forgot that men were on the cage instead of coal and that I had changed to the upper level. I opened the throttle wide and the cage came up at a terrific speed. I did not realize that it was near the top until I saw it flash past the window. The men were transfixed with horror and were clinging to each other in a frenzy of fear. One or two were on the bottom of the cage having been weakened by their inability to breathe, owing to the speed at which the car traveled.

"It is curious how fast one can think at such a time. I saw in that moment the hoist demolished, the cage smashed into a tangled mass, the rope part and the mangled men and wrecked cage dropped back into the mine a thousand feet below. This was followed by a vision of a dozen funerals, weeping women and fatherless children, and after that myself surrounded by a howling mob of avenging men who would be satisfied only with my life."

"Horrible!" I exclaimed at the vivid picture he had drawn.

"Horrible? It was worse than the tortures of hell! While these thoughts were flashing through my mind, I realized that there was a chance to save them. A hoisting engineer as a general practice does not use the band brake to stop his engine, but depends upon plugging it, or reversing, to use a more proper term. That was my chance! I brought the reversing lever over with a jerk, and although I hardly expected to accomplish my purpose in time, the engine came to a stop and began its reverse motion. After the cage had dropped a few feet I held the car suspended and, making for the door, securely fastened it on the inside. After the men had time to collect themselves, I lowered the cage to the ground level."

"Why did you keep the men on the cage instead of bringing them to the surface?" I asked.

"That was a matter of self protection, as the men in their frightened, frenzied state would have made a rush to the engine room, and had they gained admittance they would have made a short end of 'yours truly.' After they had a chance to cool down a little, although they made a demonstration, they finally went away and that ended the matter, for I resigned my position, knowing that it would hardly be safe to continue at that hoist."

"I see," I replied; "that was certainly a close call."

"It was one chance in a thousand that I was enabled to stop the cage in time, and this was only because the hoist differed from most others; that is, the cars of coal were hoisted about sixty feet above the ground level and were then run upon a trestle and into the breaker. Had the cars been run off at the ground level, as is the case with many hoists, those men would have been killed, for there would have been no time to stop before the car hit the top of the hoist. I dislike to think of it even now.

"When I settled down in a new place, where no one knew me, I decided to devise some kind of a scheme which would make it next to impossible to make a mistake."

Fig. 1. We Selected Seats and Lighted Our Cigars

"Do engineers make many such mistakes?" I asked.

Overwinding

"It is not uncommon to hear of an engineer overwinding. It is generally done, however, by his forgetting to reverse the engine and, after the car has been run from off the cage, to start up and hoist the cage and the car through the top of the head. I knew of one engineer who did that three times in as many years, but he was an exception."

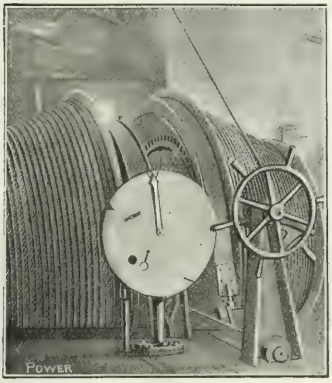


Fig. 2. Indicator Disk without Shield

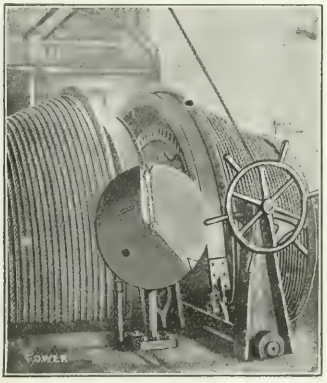


Fig. 3. Indicator Disk with Shield

"How did you arrange your safety device?" I next inquired.

"As you doubtless know, the telltale dial of a hoisting engine is put in a convenient place where the engineer can easily see it while stationed at his levers. In my case it was set almost in front of the two drums, and quite low.

"It is customary to mark the levels on the face of the dials with chalk, and in this instance the mark for the 220-foot level came at a point about one-third of the circumference of the dial, the surface level or head mark being at the top, at which position the indicator finger pointed when the cage was at the surface with the car ready to be pushed off by the headman.

"I made a false cover of sheet iron to place over the disk, so that when I was hosting from the 220-foot level there were but two marks on the dial to watch and there could be no confusion of level marks. When I had to hoist from the lower level the false cover was removed, and then of course there were three marks visible on the disk, but no attention was given to the center mark. The cover fitted loosely over the disk and was easily lifted from its position when it was necessary to change it. It was arranged as shown in these photographs." So saying, he handed me the photographs shown in Figs. 2 and 3.

"You will notice that the cover has a handle attached to assist in putting it in place."

"Quite an idea," said I, much interested.

Telltale Signal

"Oh, that was but part of the arrangement. On the face of the dial I had a small disk of flat sheet iron painted white and attached to an arm, which was operated by an arrangement attached to the rear of the large dial. While the cage was at any point between levels, this small white disk hung down, but as soon as the compressed-air signal was given the air pressure forced the arm and the disk up to an angle of perhaps 15 deg. and covered a bright red circle I had painted on the face of the telltale dial. Unless this red mark was covered by the white disk I knew that the signal to hoist had not been given and of course I would not start to hoist."

"That seems all right," I said, "but what good would the white disk do when you had the cover on the telltale?"

"It worked just the same," was the reply. "At a point just opposite the red disk I had cut a hole of the same diameter so that while hoisting the red showed through and, when the signal had been given to hoist, the white disk would come up and cover the red spot and show white, or the safe starting point. With this arrangement there could be no mistake about hoisting if one but used his eyes."

"That seems a pretty good idea, but how does that white signal disk operate?"

"I can best illustrate that by a sketch," answered Hunter, and he proceeded to make a drawing similar to that shown in Fig. 4. "You see, the shaft which I will designate as *A* has mounted upon it the disk and arm *B*, a weight pulley *C* from which a weight is hung by means of a cord, and a ratchet wheel *D*. This latter member has an arm attached to it by means of screws and it is connected to the piston of the air cylinder *E* by a piston rod.

"Just beyond the ratchet gear *D*, I made a frame on which a pawl was pivoted at *F* and fitted with a pin *G*. Then on the shaft of the indicator I put an eccentric *H* which would, when in a certain position, throw a movable shipper arm, to which was secured the projecting piece *K*. This piece was notched at the top so that when the eccentric was not bearing against the end of the shipper *J*, the pawl *L* would engage with the teeth in the ratchet wheel. The member *J* slid on the pin *M* and ran up on the pin *N* when the arm *J* was moved toward the right or away from the cam shaft, and as the outer end was lifted the extension piece *K* engaged the pin *G* and lifted the pawl so that it would not engage with the ratchet wheel *D*, and if the disk *B* was in the safe or hoisting position the weight *O* would then rotate the shaft *A* toward the lift, thus bringing the disk to a lower position ready to be thrown into the safe or working position again."

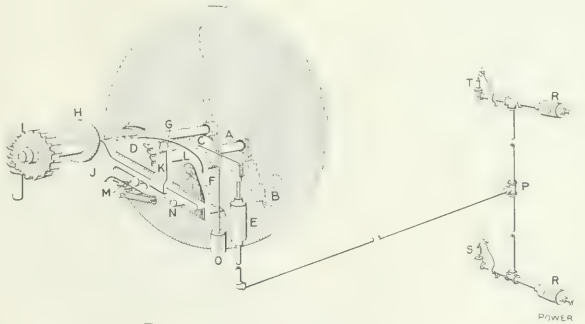


Fig. 4. Details of Safety Signal

"It had to be timed accurately, I should judge," I said.

"Yes, but that was easily done; it all centered upon the position of the eccentric *H*."

"I hardly see how air operated the

device," I remarked, not quite grasping the exact principle of operation.

"The piping arrangement was similar to that shown at *P*," explained Hunter as he sketched in the pipe line. "The arrangement operated like a charm.

"When the headmen above have removed the loaded car and pushed an empty car on the cage a bell is rung; when the foot man at the level from which coal is being hoisted has run off the empty car and put a loaded car on the cage he pushes the air plunger *R*, which operates the plunger at *S*, one in the engine room at *T* and the plunger in the cylinder *E*. The first two plungers rang a bell but the plunger *E* rotated the ratchet *D* in the direction of the arrow. This movement threw the white disk *B* to a position covering the red mark on the face of the indicator dial, which indicated that it was safe to start. When the engine was started the cam *H* came around and moved the shipper *J* toward the right, which lifted the pa l *L* and the weight *O* swung the disk *B* away from the red danger signal."

"That was quite an ingenious arrangement," I said as I studied the drawing, "and it must have been quite a help."

Just then the bell-boy began calling, "Mr. Hunter," and, excusing himself, my friend went to answer a telephone call, and I went to my room to dream of wrecked hoisting apparatus and safety devices, while a dozen or more headless, legless miners danced about my bed.

A Glimpse at a Sugar Mill Boiler Plant

By Fred H. Colvin

During a recent visit there were indications of a big crop of cane and of sugar in Cuba, some claiming a record crop, others being content to call it good. In any case, all the sugar mills were being overhauled, many of them being considerably enlarged, in preparation for the grinding season which began along in December. For, once the cane was ready, the grinding must go on day and night for four or five months, or until finished.

In a general way, the power plant of a sugar mill may be compared to that of a rolling mill. The engine is connected to the train of grinding rolls in much the same way as in a rolling mill, and the amount of power required is very heavy. The cane is first fed between the breaking rolls, which have deep corrugations and look like many pairs of herringbone gears on a single shaft. The finishing rolls are plain and are set very closely together. They squeeze the cane so dry that it drops on a conveyer and goes direct to the furnaces to be burned.

At the Providencia Sugar Mills, which I visited, the machinery was a strong mixture of American, British, French and German, the engines being built in Glasgow while the electrical apparatus, such as the motors on the centrifugal separators, was mostly American.

Leaving the last pair of rolls, the dry cane or bagasse drops on a large conveyer and with a few changes reaches the top of the boilers in the conveying belt *A*, as can be seen in Fig. 1. A chute *B* is provided for each pair of boilers, going down between them and feeding two furnaces. The furnaces are approximately 7 feet wide by 9 feet long, the grates covering nearly the whole surface of the furnace. The grate is about one-half air space, the bars and openings being about 1 inch each in width.

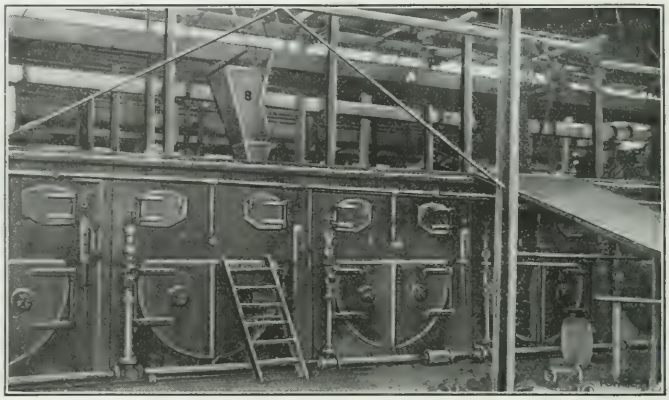


Fig. 1. Boiler Fronts, Showing Method of Feeding Bogasse

With the exception of starting the furnaces at the beginning of the season, bagasse furnishes the entire fuel supply at this mill, and this is said to be general in Cuba where economical engines, generally of the Corliss type, are used. In Louisiana the cane is less woody and steam economy is very important as the bagasse does not supply over two-thirds of the fuel. The furnaces are started with wood. Forced draft is used, two blowers being provided, one at each end of the battery of 10 boilers, so that either or both can be used as necessity demands. A little idea of the furnaces, ashpits and blower connections can be had from Fig. 2. The ashes are raked out from beneath and wheeled away by hand. They are rather fine and are used as a fertilizer on the lands of the plantation.

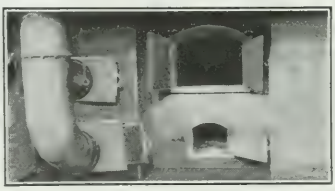


Fig. 2. Blower Connections

As few of the men on native Cuban or Spanish plantations speak English, and as nothing much below the position of chief engineer is at all financially attractive to an American, the field in Cuba for the readers of Power is decidedly limited.

There is nothing to fear in the climate, which many Americans find delightful in most ways, but sanitary conditions, schools and society on a sugar plantation leave much to be desired for those who are accustomed to towns or cities, the nearest comparison being a large ranch in the West, with the odds in favor of the West.

Smelter Fumes Abatement

E. G. Cottrell, of San Francisco, an expert in the employ of the Federal Bureau of Mines investigating the smelter fumes problem, announced at the convention of the American Chemical Society that he and several Californians associated with him had turned over their patent rights in a device for the suppression of this nuisance to the Smithsonian Institution and that the gift had been accepted.

Mr. Cottrell began his investigations into the problem of smoke from smelters several years ago while a professor at the University of California. He soon reached the point where his device should be put in operation at a large plant and a number of others connected with the university joined with Mr. Cottrell in the undertaking, as it required considerable money. The apparatus has been installed at a number of plants and has been so successful that it is believed the smelter fume nuisance will soon be abated.

The royalties will be used to aid other investigators to bring their ideas to practical accomplishment.

A New Type of Fluid Motor

If a pair of spiral or herringbone gears are held together as in Fig. 1, here will be found to be a lozenge-shaped pocket in the center, as at *a* in Fig. 2. If the gear is revolved, this space is extended, and as the teeth inclosing it advance to the respective positions, the volume will be increased to that shown at *bcde* and *f*.

A fluid under pressure admitted to the space *a* and acting upon the receding surfaces would drive the gears, the energy produced being equal to the product of the pressure and the volume generated. If the driving fluid were expansible and were cut off at any point, it would expand into the increasing volume, and the advantages and economies of expansion be realized just as in a cut-off engine working with a regular piston. When the ends of the grooves in which the action occurs pass the line of contact so that they are no longer closed by the teeth of the opposite gear, the fluid would be exhausted, as indicated at the end of the gear in Fig. 2.

It is upon this principle that the "Spiro," a new type of motor invented by John H. Van Deventer, superintendent of the Buffalo Forge Co., acts. The operating fluid is admitted through ports *pp*, Fig. 2, and one of the claims to turbine classification, for the inventor insists that it is a turbine, is that the gears are driven as well by the impact as by the pressure of the entering air or steam. There is no intention, however, to produce a considerable drop between the steam chest and the admission pressure, and no nozzle or other means is used for inducing velocity. The width of the entrance port in the axial direction determines the point of cutoff. The regulation may be effected by varying the cutoff by an adjustable port, or by throttling; inclosed forms of both types of governors being furnished.

With a given mean effective pressure the capacity of an engine is proportional to the volume which it generates; that is, to its piston displacement. As this displacement is the product of the piston area and speed, or of the factors *LAN* in the common formula,

$$Hp. = \frac{PLAN}{33{,}000}$$

we may write

$$D = LAN$$

and

$$Hp. = \frac{P}{33{,}000} \times D$$

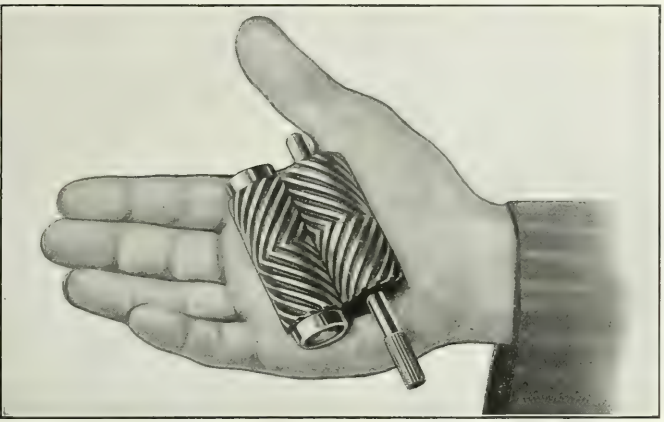


FIG. 1. THE ROTOR OF THE SPIRO MOTOR

The secret of the large capacity of this little motor lies in the large displacement afforded by its numerous chambers and the high velocity at which their volume is increased.

Assume a gear 8 in. in diameter with teeth 1 in. in depth. The annular space between the roots of the teeth and the casing would have a cross-section of about 22 sq.in. As one-half of this space is occupied by teeth and one-half available for displacement on *each* gear, the available volume would be that of the whole space considered with reference to one gear.

Assume the length to be 24 in. and the speed 2000 r.p.m.; then the displacement will be

$$22 \times 24 \times 2000 = 1{,}056{,}000 \text{ cu.in.}$$

or 611 cu.ft. per min., which is about that which would be generated by a piston 13¾ in. in diameter running at 600 ft. per minute.

It is possible, therefore, to get a large amount of power into a small weight and space with pure rotary motion, no pistons nor abutments, and with no necessity for packing. The surfaces of the teeth, as the gears drive each other, run in sufficiently close contact to preclude serious leakage; leakage between the tops of the teeth and the casing is minimized by the small pressure difference between contiguous grooves, and what steam is present between the teeth forms an elastic cushion reducing tendency to wear. The contact pressure imposed upon the teeth does not exceed 5 lb. per square inch, which is very small compared with that used with gears designed for power transmission. The ends being in the exhaust chambers do not require to be packed. The reaction of the steam as it escapes after its release at these points is another claim which is urged for classification as a turbine.

A little study of Fig. 1 will show that the steam is exhausted while the chamber in which it has been working is still above the center. There is, therefore, a greater pressure upon this upper surface than upon the under one. This unbalanced pressure is carried directly upon the bearings, which are made ample to withstand it, and are so constructed that each acts as its own oil pump, circulating oil between the shaft and bushings under a constant pressure. In the actual engine the under surface of the gears is the active one, the exhaust being on top. The weight of the gears is thus opposed to the unbalanced pressure. Or the gears may be set one above the other, as shown in Fig. 6.

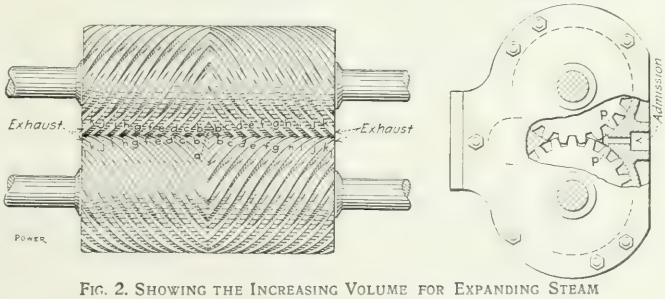


FIG. 2. SHOWING THE INCREASING VOLUME FOR EXPANDING STEAM

The "Spiro" is to be built in sizes all the way from small units, which may be held in the hand and used to operate drills and other air-driven tools, up to those of several hundred horsepower.

The rating is based upon 100 lb. gage initial pressure and 2000 r.p.m., noncondensing. Patterns up to 60 hp. are now ready, and the dimensions and weights are given in the accompanying table. The construction is extremely simple, consisting essentially of only five parts—the case, two runners and two heads, Figs. 4 and 5.

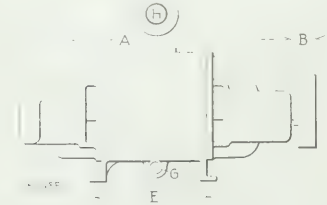
We have known for some time of the work which was being done upon this motor, but the inventor and projectors have been unwilling that anything should be said about it until it had been thoroughly tried out. After three years of development and experiment they announce it as ready for the market.

The 186-hp. unit shown in Fig. 6 has been in use for three years by the Buffalo Forge Co., driving fans, gas scrubbers and other apparatus requiring a running test. It has never been taken apart, nor needed a single adjustment in that time. Noncondensing tests with smaller units show the following results:

	Test 1	Test 2
Boiler pressure, lb. gage	120	130
Initial pressure, lb. gage	101.5	115
Horsepower	25.3	151
Speed, r.p.m.	2150	2710
Water per brake horsepower-hour, lb.	53.2	31.5

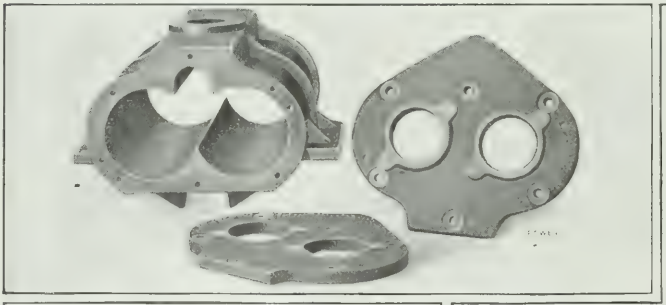
The small hand motor, the rotors of which are shown in Fig. 1, will run a ¼-in. drill into hard cast iron at the rate of one inch in twelve seconds.

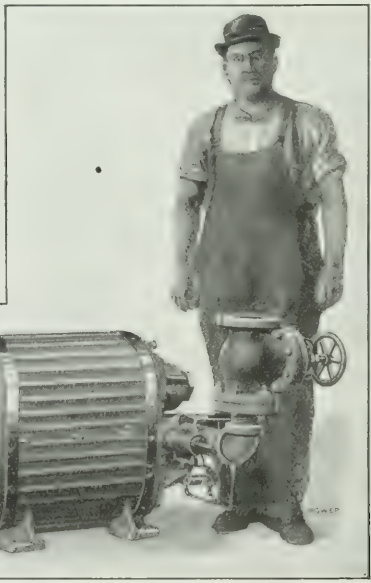
Fig. 3 shows a 5-hp. unit, being operated by steam from an ordinary tea-kettle; the ¼-lb. pressure which this kettle will carry being sufficient to start it and keep it in motion.

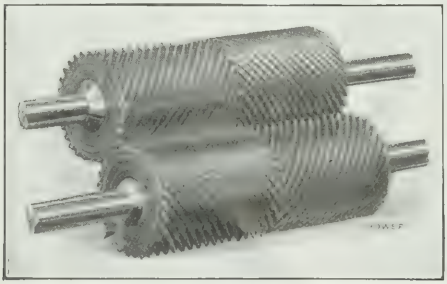


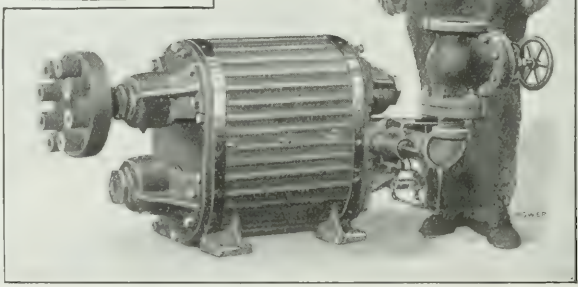
Hp.	A	B	C	D	E	F	Steam Type G	Exhaust Type H	Wt. Turbine only
1–3	16½	3	2½	8½	8½	5¼	¾	1½	100
3–5	19½	3	3	9½	10½	6½	1	2	175
5–10	30½	3½	3½	11½	13½	7½	1½	2½	300
10–20	36½	3½	4	14½	16½	9½	1½	3	550
20–30	45½	4	4½	16	19½	10½	2	4	800
30–40	49	4½	5½	18½	22	12½	2	4	1200
40–60	57½	5	6	20½	25½	13½	2½	5	1600

Fig. 3. A 5-hp. Spiro Run by a Tea Kettle









Figs. 4, 5 and 6. The Casing and Heads, the Rotors and Unit of 186 Hp. Capacity

Lubricants, Their Properties and Uses

By Robert Jeffrey

Animal and vegetable oils, although containing acids detrimental to the metal surfaces, possess greater oiling properties than mineral oils and when blended with the latter make very satisfactory lubricants for certain purposes.

In special cases, however, only mineral oil should be employed.

*From a paper read recently before the Practical Refrigerating Engineers' Association, at Houston, Tex.

All animal and vegetable oils, fats, etc., contain acid constituents which will attack the metallic surfaces of bearings and form soaps of iron, copper, etc. The tendency which they have to become more acid with age is very slight in most cases, if the oils are properly refined and not stored too long.

Grease

When a grease is rubbed between the fingers they will slide freely over one another even when pressed together with considerable force. A similar effect is produced when a greasy finger is rubbed over a sheet of glass or other smooth solid. This arises from the fact that the grease is not a liquid or viscous substance, but a plastic or very soft solid which cannot by pressure alone be wholly driven from between the surfaces. On the other hand, the soft solid is easily sheared, the resistance offered to the sliding of particle over particle being very small. This property of greases causes them to form very thick lubricating films, even when the loads are heavy and the speeds moderate. At high speeds, however, they do not compare favorably with the oils, the frictional resistance being much greater; hence, except for special bearings, greases are now giving way to blended oils.

Greases are generally made by thickening a mineral oil, fixed oil or fat with a soap of lime, soda, lead, etc., more or less water being emulsified with the oil and soap. In some cases solids, such as black lead, French chalk and mica, are also added. They are liable to be adulterated with excess of water, and with solids such as China clay and gypsum, which are not lubricants.

Oils

The corresponding property in the case of liquids, which prevents the lubricants from being easily pressed out, is called oiliness. Different liquids possess this property in very different degrees. Thus, although sperm oil is much less viscous than glycerin, it will be found to be a much better lubricant. The viscosity of an oil, therefore, by no means furnishes an index of its lubricating value.

For ordinary speeds, moderate loads and good lubrication, it is no doubt the degree of fluidity which principally determines the value of a lubricant for any particular purpose; but when the speeds are slow or very high, the loads great, or the lubrication imperfect, oiliness as well as viscosity plays an important part in a reduction of frictional resistance. The property of oiliness is generally possessed most markedly by the animal oils, less so by those of vegetable origin, and least of all by some mineral oils. It is on this account that mixed oils are so frequently added to mineral oils, for they give the latter the property in which the mineral oils are most deficient.

Each particular animal or vegetable oil has a viscosity which does not vary greatly in different samples, and may be regarded as being in some measure an indication of its purity. The viscosity of such oils, therefore, need not be specified when ordering, but should be determined for the purpose of ascertaining the probable purity. Mineral oils, however, have a great range of viscosity, and it is necessary to state in all cases the degree of fluidity required. The viscosity of all lubricants varies considerably with the temperature. Thus, an oil which, as long as the journal runs cool, is sufficiently viscous to carry the load properly, may become so fluid, if the temperature should rise, that the rubbing surfaces tend to grip.

Mineral Oils

Mineral oils being much cheaper than the better grades of fixed oils, and at the same time possessing valuable properties which they confer upon other lubricants with which they are mixed, the use of blended oils has now become common. Apart from the pecuniary aspect of the case, the blended oils are for many purposes superior to either pure fixed oils or pure mineral oils. The percentage of mineral oil permissible varies according to the load, speed, etc., for many mineral lubricants are deficient in oiliness and can seldom be used pure, except in special cases or where bath rings or forced lubrication are used, and the journals and bearings are kept flooded with oil. At one time mineral oils were regarded with great distrust both by chemists and engineers, and when found mixed with fixed oils they were regarded as objectional adulterants. The reverse now seems to be the view often taken, fixed oils being sometimes looked upon as adulterants when found mixed with mineral oils.

Pure mineral oils are suitable for pressures below 70 lb. per square inch with free lubrication, when the metal surfaces in contact are such as do not readily seize one another. With increasing loads the proportion of fixed oils which it is desirable to add must also increase, if satisfactory results are to be obtained as regards friction and wear. From a chemical point of view there are good reasons for mixing as large a proportion of mineral oil with any fixed oil as will not interfere seriously with its load-carrying properties. By such admixture the tendency to gum is checked, the oil remains fluid and cotton waste saturated with it is much less liable to fire spontaneously. Animal and vegetable oils cannot, however, be added to all mineral oils with impunity; solid hydrocarbons are present in some mineral oils, which, when they are mixed with vegetable oils, separate out as a precipitate and cause trouble by clogging.

To clean surfaces which have become covered with a gummy oxidized lubricant, the parts should be well moistened with paraffin oil, which dissolves the gum. They should then be allowed to run for a few minutes, after which they may be wiped dry and clean.

A large number of lubricating greases are made by incorporating emulsifying animal and vegetable fats with soap and water, also by thickening mineral lubricating oil with soap. These greases are used with very good results on railway-car axles, and some of them are excellent lubricants for the bearings of slow-moving machinery. When the loads are exceptionally heavy, solids, such as plumbago and soapstone, are sometimes added to the grease. These solids prevent abrasion at points where the pressure forcing the surfaces together is very great. Except in special cases, however, greases should not be used for fast-running journals, shafts or spindles, as the frictional resistance which they offer to the relative motion of the surface causes great loss of power.

Impurities

Before rejecting any particular lubricant because difficulty has been experienced owing to the heating of the bearing supplied with it, care must be taken to ascertain whether the fault really lies with the lubricant or with impurities accidently introduced. In transparent oils these are easily seen, but in the thicker dark varieties they are almost entirely invisible. When oil contains such impurities as sand, mucilage, or precipitated paraffin, etc., which it very commonly does, and is poured into oil cups

in the usual way, the solids are filtered out or settle to the bottom of the reservoir and do not get into the bearings. But engineers frequently go round their engines and pour a little oil into the ends of the bearings, or even remove the oil pads and pour directly upon the bearing surfaces; this introduces grit at points where it can easily get between the rubbing surfaces.

Films of various kinds also settle on the trimmings or obstruct the oil passages and prevent the oil from finding its way with the necessary freedom to the working surfaces. To still further reduce the risk of small particles of grit entering into the oil cans, the lubricant, as it is given out for use, should be carefully strained through wire or cotton gauze when drawn from the tanks.

To enable nuts, boiler manholes and handhole plates, keys, etc., to be easily placed in position and removed again after standing for months or years in warm places, a lubricant is required which retains its qualities and does not evaporate, corrode or otherwise injure the metallic surfaces. For such purposes tallow or oil or greases containing it should on no account be used. No doubt they make the nuts, etc., work freely in the first instance, but in a very short time the fat undergoes a change which corrodes the surfaces together Even mineral oil, although it does not set up corrosion, flows out of the joint in the course of a few hours when heated, evaporates, and leaves the surface free to bind.

To prevent this, the best plan is to make use of a lubricant consisting of thick mineral cylinder oil or petroleum jelly mixed with blacklead. Here, even if the fluid or semi-solid portion of the lubricant should be driven out of the joint, the blacklead remains in the joint, keeps the surfaces free and enables the nuts to be easily tightened or taken off at any time without risk of breakage. The same applies to valves, valve fittings, etc.

Unnecessary Wear

Although it is impossible to so lubricate the cylinders and valves of a steam engine that there will be no unnecessary wear, it is impossible to obtain anything like the results, so far as friction is concerned. The piston and valves move to and fro in straight lines and do not tend to place themselves in such positions as to trap the oils properly and keep the surfaces from touching. Neither can the large extent of surface exposed be kept flooded with oil. Therefore, it is necessary to be content with the presence of a lubricating film of no great thickness, and either make the loads on the bearing surfaces small or cause them to move somewhat slowly.

Corrosion

Vegetable and animal oils are unsuitable for cylinder lubrication, as in contact with the steam at the high temperatures to which they are subjected, they undergo a chemical change resulting in the formation of free fatty acids which give rise to very serious corrosion. In many instances, the use of such fatty lubricants has resulted in the cylinder metal being rendered spongy and porous in the course of a few years; bolts, valves, spindles, studs and other parts have been cut quite through, and the cylinder joints, etc., rendered leaky. Fatty oils, however, when mixed with mineral oils, in quantities not exceeding 5 to 20 per cent., do not seem to produce these objectional results so readily; indeed, the lubrication of parts which have to carry very heavy loads is greatly improved by the addition of such oils.

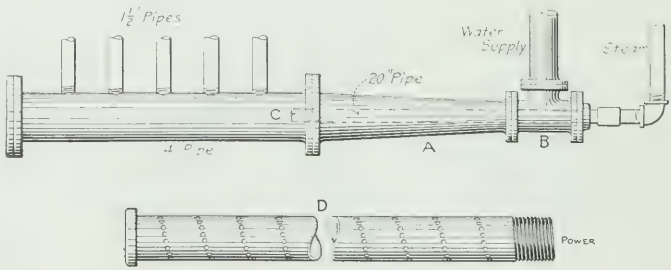
When surface condensers are used and condensed water is again passed into the boilers, care must be exercised to prevent the passage of oil used for lubrication of the cylinders into them. Tallow, suet, castor oil and other animal and vegetable lubricants must not be used in such cases, even in small quantities, for the acids liberated by the action of heat and water vapor pass into the boilers and cause serious corrosion. These acids cannot be separated from the water by merely allowing it to rest for a time in a tank; they remain to a large extent suspended in the water, giving it an opalescent appearance. Mineral oils also remain suspended in condensed water in a very fine state of division, and even though a considerable quantity may rise to the surface and be removed, sufficient may remain in suspension to produce a very serious effect upon the flues by so checking the passage of heat through the boiler plates as to cause them to burn.

The deleterious effects produced by the action of a lubricant on marine boilers when surface condensers have to be used, have led to marine engines being run without any direct lubrication of their valves or cylinders whatever, although a certain amount of oil finds its way in from the swabbing of the piston rods and valve stems. This can often be done without any serious wear taking place as the load on the rubbing surfaces of many well designed engines is very small, but with new engines slow speed must be adopted to begin with, and the surfaces allowed to burnish and acquire hard skins.

Heating Large Quantities of Water Quickly

A scheme for heating large quantities of water quickly is shown in the accompanying illustration. The device consists of a section of 4-inch pipe from which various outlets are run by means of suitable connections to various points of delivery. Connected to the flange of the header or manifold is a section *A*, 20 inches long. A tee *B* is fitted to this section and is reduced for a 1½-inch steam pipe *C* in which three hundred ¼-inch holes have been drilled spirally as shown at *D*.

The holes are drilled on a slant toward the capped end so that as the steam is forced through them it imparts momentum to the water, and the spiral arrangement of the holes produces a whirling motion which thoroughly mixes the water with the steam, thus permitting a large amount of water being heated with a small amount of steam. The water supply enters the section *B* at the top inlet.



Details of Header

Much has been written recently to impress the mind of the isolated-plant engineer with the necessity for keeping records of his plant's operation if he desires to check the inroad of the central station into his domain.

Comparatively few letters have come to this paper from engineers telling how they succeeded in repelling the central-station advances. These few letters are surely not an index of the amount of good work done along these lines by the many engineers of isolated plants, and it is hardly to be believed that these engineers are indifferent to the dangers that confront them in the activity being displayed on every hand by the central-station solicitor.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Holzwarth Gas Turbine

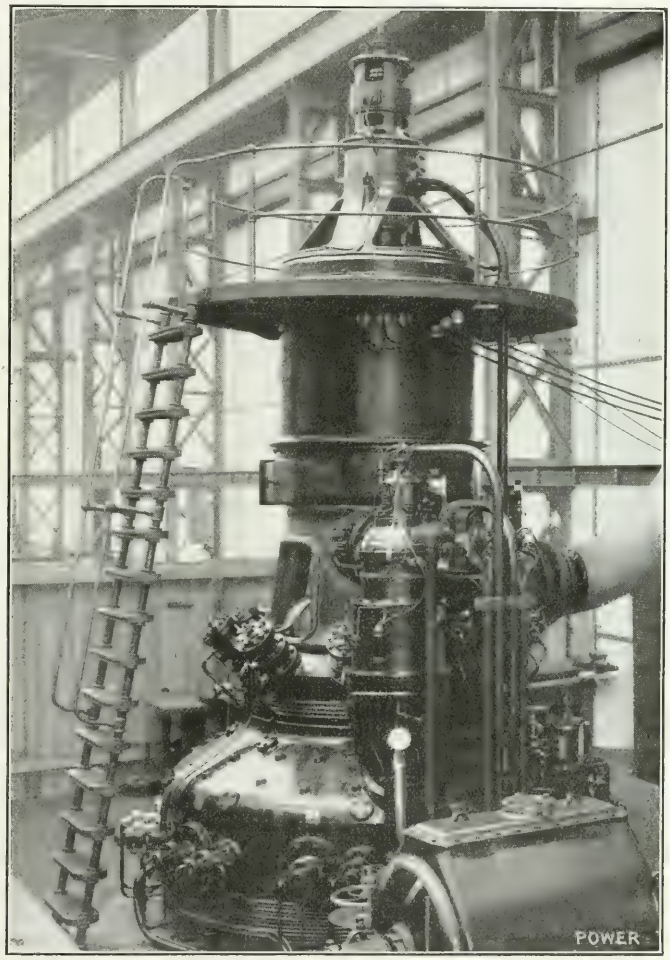
In a book just published in German, Mr. Hanz Holzwarth, a well known gas-engine designer, describes the construction of a new type of gas turbine which he is developing and presents the results of three years' painstaking experiments and investigations. This work is of a high degree of industrial importance, and the results obtained by Mr. Holzwarth are most interesting and should be valuable to anyone seriously interested in the gas turbine problem.

In a paper recently read by Mr. Holzwarth before one of the German engineering societies he pointed out that the history of the development of the gas turbine suggests two ways of solving the problem. In the one method, the mixture of air and gas is brought to the combustion chamber under the highest possible pressure, and there burned continuously; the outlet of the chamber is fashioned into a nozzle in which the compressed gases are expanded and a high velocity given to them, which with a proper form of turbine is converted into mechanical energy. This is the method of Lemale. The other method consists of intermittently burning the fuel in the combustion chamber and then scavenging the chamber with a cooling medium. This is the method Mr. Holzwarth has chosen.

Fundamental Principles

The combustion chamber is filled with the explosive mixture, then follows the ignition and explosion, the increasing of the pressure of the gases, followed by expansion through a nozzle upon a proper form of turbine runner; then a thorough scavenging and cooling of the combustion chamber with fresh air. Mr. Holzwarth's tests and investigations, he says, indicate that the explosion turbine is practicable only if the principle illustrated in Fig. 1 is followed. In this drawing *A* is the combustion chamber; *B* is the air chamber; *C* is the gas chamber; *D* is a mechanically controlled admission valve for air; *E* (not shown) is a mechanically controlled admission valve for gas (a spraying or atomizing nozzle to be used for liquid fuel); *F* is a nozzle valve; *G* is a nozzle; *H* is the turbine wheel; *J* is the exhaust passage.

By means of a blower of any sort, driven in any desirable way, the chambers *B* and *C* are filled with air and gas respectively, while a low pressure is maintained in the exhaust passage *J* by means of an exhauster. Through the admission valve *D* air is taken into the combustion chamber *A*; after the chamber is full of air, the gas is admitted through a similar valve, and the whirling thus produced causes intimate mixture of the gas and air. During this time the nozzle valve *F* remains closed. Immediately after the ignition, the valve *F* is automatically opened by the explosion pressure and the gases go through the short passage to the jet *G*, and acquire in it the velocify corresponding to the available energy contained in them.



Holzwarth's 1000-hp. Gas Turbine

This kinetic energy is converted in the turbine wheel *H* and the expanded gases pass off through *J*. After the passing off of the expanded gases the nozzle valve *F* is mechanically closed, but so slowly that

the scavenging air now entering through *B* has enough time to clean and cool the chamber and the turbine. A number of such combustion chambers are arranged in a circle around the turbine axis and their operation follows in definite rhythmical order.

The First Industrial Machine

Fig. 2 shows the construction of the first Holzwarth gas turbine built on industrial lines. It uses ordinary suction

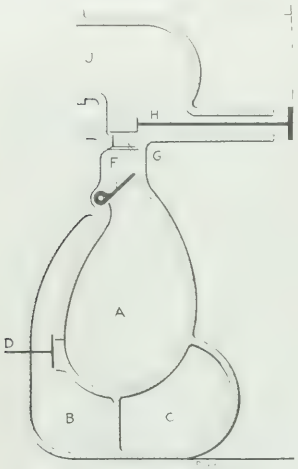


Fig. 1. Schematic Diagram

producer gas of 123 to 135 heat units per cubic foot and was designed for a maximum capacity of 1000 hp. at 3000 r.p.m. It was built to Mr. Holzwarth's design by the well known Swiss firm of Brown, Boveri & Co. With this machine the principal investigations and tests were made during the past year.

Upon the ring of combustion chambers is built the lantern frame for the dynamo, with the lower collar bearing for the turbine shaft. On the lantern the dynamo is set and above this the upper collar bearing and the "step" bearing. The turbine shaft, therefore, hangs freely suspended from the upper end, with the turbine wheel at its lowest extremity. The shaft passes through the turbine casing without a stuffing-box and there is no other structural element connected with the turbine case. The turbine wheel and dynamo rotor are mounted on a rigid through shaft with out any coupling as shown in Fig. 3.

The explosion chambers contain all means for the control of their own processes. About the assembled explosion chambers arranged in a circle are the gas chamber, the passage for the air, which if desirable is cooled with water, cooling water conduits, the gas- and air-admission valves and the nozzle valve. In front of the outlets of the explosion chambers the nozzles are arranged. The stationary blades of the turbine are likewise bolted against the upper part of the explosion chamber. The upper flange of the explosion chamber carries the lantern and the turbine case is also bolted to it, the case carrying the flanged opening for the exhaust.

The explosion chambers are given an ellipsoidal form; the lower end is pressed inward, the upper drawn down to accommodate the seat of the nozzle valve, as indicated in Fig. 2.

As material, Mr. Holzwarth considers that cast iron merits first consideration. The pressure need not run so high as in the piston engine, 10 atmospheres being

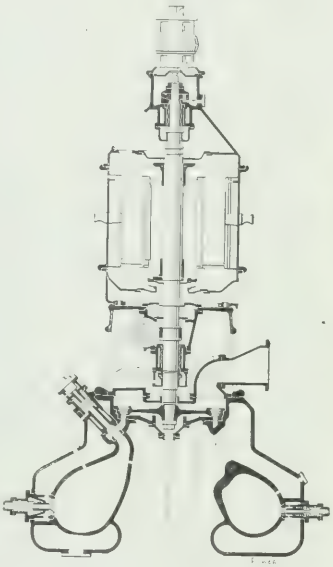


Fig. 2. The 1000-hp. Turbine

sufficient, and the automatic opening of the nozzle valve immediately after ignition avoids the possibility of damage from high pressure. Moreover, the Mellipsoidal form of the chamber is better adapted to resist internal pressure than a cylinder with equal thickness of wall. These features permit the use of a light-weight structure. The whole gas turbine, without the dynamo and blower, weighs some 25,000 kilograms (55,000 lb.), as compared with 140,000 kilograms (310,000 lb.) for a 1000-hp. piston gas engine without the flywheel.

As the air and gas valves regulate the supply of gas and air for the combustion chamber, there are as many air and gas valves as there are combustion chambers. On account of the multiplicity of organs, which in themselves are exceedingly simple, it is important that simplicity and dependability should characterize the method of speed regulation. For this reason the oil-relay principle is used, thereby avoiding a multiplicity of oscillating levers, pins, eccentrics, etc. There is only a piston to actuate each valve, the piston being moved by oil under pressure and controlled by means of a rotating distribution valve.

Each of the valves operated by oil under pressure is also provided with a device for periodic regulation, this being operated also by means of oil pressure under the control of the governor. Fig. 4 shows the construction of this valve. The body is bolted to the explosion-chamber ring, as shown in Figs. 2 and 5. The valve disk lies against a seat in the end of the valve body and the spindle slides in a bushing in the body and carries a piston at the other end. This piston is freely movable in another hollow piston, which is moved in the valve body by the oil pressure, and the movement of the hollow piston is transmitted to the

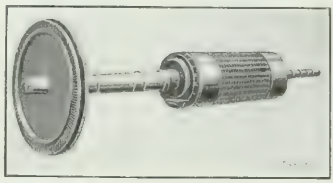


Fig. 3. Holzwarth Rotor

valve piston if the space between the valve piston and the closed end of the hollow piston is full of oil.

The function of the nozzle valve is simply to shut off the explosion chamber during the charging process. It is automatically opened by the explosion and held open during the ensuing expansion and the scavenging period. The

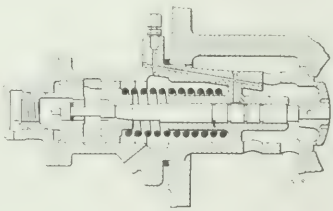


Fig. 4. Oil-controlled Valve

nozzle valve consists of the valve body, the valve with the spindle, a spring-loaded disk and the actuating piston, which is moved by oil pressure. The spring holds the valve closed with a pressure sufficiently high to prevent the escape of mixture during the charging process. After expansion is completed, oil is admitted to the actuating cylinder and holds the piston up and the valve open until the scavenging is accomplished.

The horizontal governor shaft is enclosed by a housing which is bolted to the lantern frame, and it is driven through a worm-gear between the lower collar bearing and the dynamo, as indicated in Fig. 5. Upon the governor shaft are keyed the governor; a safety stop, which in a simple manner cuts out the ignition; the tachometer drive; the worm-gear for driving the vertical regulating oil-distributor, and the drive for the ignition mechanism.

The regulating organ proper is the rotating oil-distributor. The pistons for operating the intake valves, nozzle valve, gas valve and air valve for one combustion chamber are controlled by one rotor and the several rotors are mounted upon a shaft which turns with an angular velocity corresponding to the number of cycles per chamber. In the stator of the oil distributor are equally spaced axial slits which communicate with the oil cylinders of the valves. The oil is pumped under pressure into the rotor, from which it flows through the slits in the rotor and the slits in the stator to the valves, which are thereby operated in definite sequence. When the rotor opens the slit in the stator for that purpose, the oil flows back under the pressure of the valve spring to the space in the upper part of the distributor, and passes thence to the pump. The throttle valve, with the cylinder for periodic regulation, is also bolted upon the explosion chamber (Fig. 6).

The collar of the governor is connected with the horizontal lever of the governing mechanism proper. This consists principally of what Mr. Holzwarth calls a "servo-motor," operated by oil under pressure, the throttle valve and the periodic regulator. The servo-motor is of the familiar form comprising a cylinder, piston and pilot valve. The piston rod pushes downward upon the spindle of the throttle valve without being rigidly connected to it. At its upper end the piston rod carries a small piston for the periodic regulating.

The throttle valve differs from the normal construction in that it is opened by a spring. The throttle-valve spindle follows the piston rod of the servo-motor through only a portion of its stroke; the stroke, on account of the periodic regulation, is somewhat long, and it would be useless to give its entire travel to the throttle valve.

The periodic regulation is effected by means of a small control plunger, moved by the servo-motor piston rod and travelling in a bushing with lateral ports that communicate with the regulating spaces of the gas and air valves. Under the control plunger is the oil under pressure. Above it the oil can flow off freely. The higher the plunger is lifted, the more slits are exposed for the escape of the pressure oil and the more combustion chambers put into action.

The explosion efficiency will be the greater the greater the ratio of expansion and the lower the final temperature after expansion; also, the smaller the amount of heat lost to the walls, of course. It is identical with the indicated efficiency that would be obtained from the piston gas engine if the gas mixture were not compressed after admission and the expansion were carried down to the pressure of the atmosphere. The working process in the turbine proper corresponds with that of the older Parsons steam turbine, working with steam puffs. At the moment when combustion is complete, the chamber is full of gas containing the available heat energy. As the heat is taken out during expansion, the gas passes out with diminishing velocity until the heat fall is entirely equalized. Fig. 7 illustrates this intermittent process; *W* represents the work actually realized from *C* kilograms of charge; *L* represents the turbine losses and L+W= the work which would be accomplished by a perfect engine with no loss. The height *H* of the diagram represents the available heat in the gases.

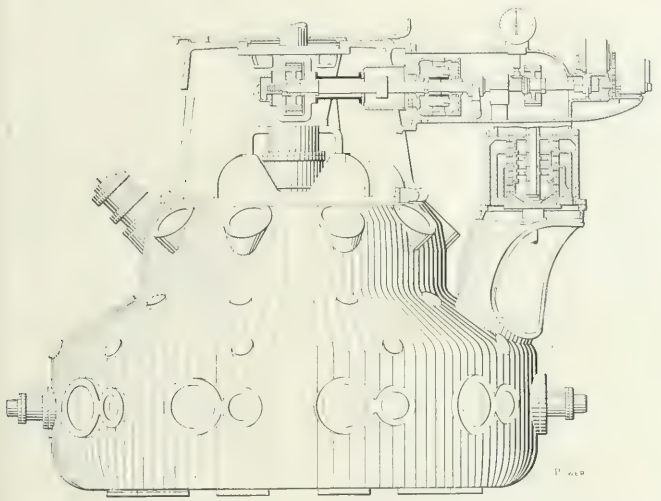


FIG. 5. SHOWING DETAILS OF GOVERNOR AND OIL REGULATOR

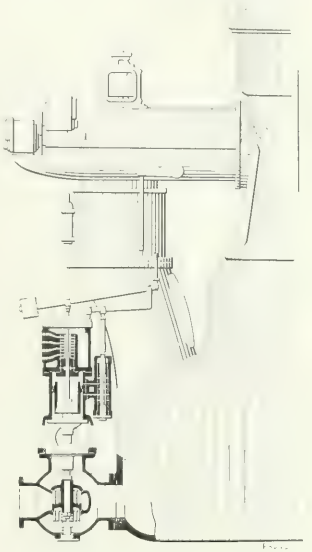


FIG. 6. SERVO-MOTOR

The air scavenging is absolutely necessary in order to keep the temperature in the turbine within reasonable bounds (about 400 deg. C.). In order to secure economical scavenging and small radiation to the walls of the explosion chamber, it is well to have the greatest possible nozzle-valve opening; for economical charging, this valve should be held closed, of course, during the charging process.

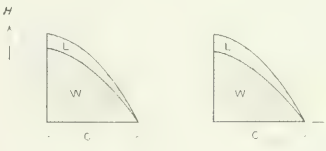


FIG. 7. HOLZWARTH CYCLE

The blower work necessary to the process is effected by the utilization in a regenerator of heat from the exhaust gases. It is, therefore, not a burden upon the heat balance of the turbine. The surfaces necessary for the regenera-

tor Mr. Holzwarth says, are not greater than those of a surface condenser for a steam turbine of like capacity.

Temperature before Ignition

A point of considerable importance is the influence of the temperature of the mixture before ignition. Upon this depends the result of ignition: whether quiet (slow) combustion or violent explosion (detonation). Upon it depends further the stability of the process, and, preëminently, the explosion efficiency. It determines, therefore, whether the pure motor process or the undesirable heat process is effected by the combustion of the fuel.

Fig. 8 shows several pressure curves for carbon monoxide. By "combustion pressure" is meant in general explosive

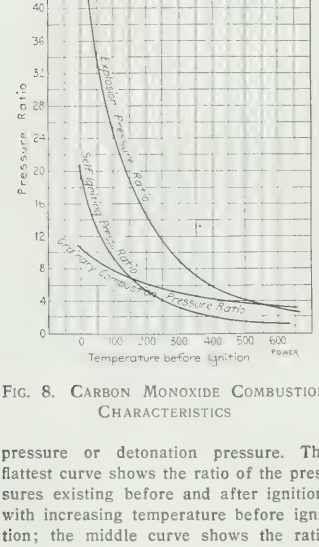


Fig. 8. Carbon Monoxide Combustion Characteristics

pressure or detonation pressure. The flattest curve shows the ratio of the pressures existing before and after ignition, with increasing temperature before ignition; the middle curve shows the ratio of critical compression pressure to precompression pressure in relation to the temperature before ignition; the upper curve shows the ratio of detonation pressure to pre-ignition pressure, indicating the explosion wave peaks which were reached as soon as the pressure reached the critical point of instantaneous, detonating self-ignition.

For example, should the temperature in the explosive gas before the ignition amount to 100 deg. C., the combustion, or explosion pressure, would be 7.7 times as great as the initial pressure. It is attained in some 0.03 to 0.06 of a second, through a regular, orderly flame propagation. In this case the critical temperature cannot be reached, for at 100 degrees this ratio to the initial pressure is 9.1.

Should the initial temperature, however, reach 400 deg. C., soon after the regular ignition half of the available gas would reach the critical temperature and the remaining half would be exploded spontaneously, and thereby produce a concussion up to 5.7 times the initial pressure while the regular explosion pressure would be only 4.3 times. At 200 degrees 14 times the initial pressure can be reached as against a normal of 6 times the initial.

This entirely unexpected and not always welcome increase of pressure does not bring a corresponding increase of capacity with it, for it is only momentary, not sustained. Fig. 9 illustrates this process.

The First Experiments

The first turbine designed by Mr. Holzwarth was a small experimental machine, which was built by Körting Brothers in the year 1908. The air for combustion, scavenging and cooling in this machine was delivered by means of a rotary blower and the fuel gas was supplied by a similar blower. Each blower was driven by an electric motor. After leaving the turbine wheel the exhaust gases, mixed with the scavenging air, passed through vertical pipes to the atmosphere.

The construction of this small experimental turbine was in principle identical with that of the larger turbine already described.

The object of the test with the first small turbine was to determine in the first place if the sought-for process was attainable, if the explosion would approach the theoretical possibility, if the scavenging and cooling were sufficient to permit sustained operation without endangering the machine mechanically, and if the vanes would stand the process. No one of these questions could be answered by the indications of other tests or by the analytical comparison of this with other machines.

The first difficulties were relatively easy to overcome. After a few weeks the machine ran mechanically perfect; the process was, therefore, practicable. No mechanical damage to the machine appeared; the nozzles and blading showed not the slightest signs of trouble, notwithstanding it was operated until the fire played upon the wheel. These tests were carried on with gas made from anthracite, and containing over 20 per cent. of hydrogen and somewhat heavy hydrocarbons.

Encouraged thereby, Mr. Holzwarth proceeded to the construction of an economical turbine adapted to the requirements of a power plant, and this was the 1000-hp. machine first described. The project was begun in 1909 and the erection was completed in the winter of 1910. Meanwhile, experiments with the small machine were continued. For fuel there were used lighting gas, heavy motor benzine, Roumanian gas oil, benzol and coal dust from various sources. Coal gas can be used in the same apparatus as power gas, but the travel of the gas valve must be materially reduced. The liquid fuels were generally pumped into the turbine by means of a Diesel injector and atomizer. The ignition remained the same (high tension jump spark).

Lighting gas gave not the slightest difficulty. Its high hydrogen and carbureted hydrogen contents made it possible to promptly ignite the entire contents of the chamber. All of the liquid fuels either pure or mixed with illumi-

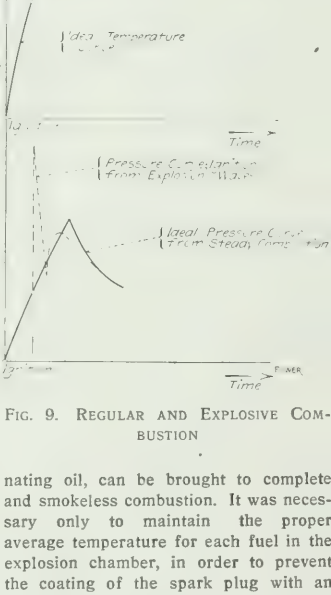


Fig. 9. Regular and Explosive Combustion

nating oil, can be brought to complete and smokeless combustion. It was necessary only to maintain the proper average temperature for each fuel in the explosion chamber, in order to prevent the coating of the spark plug with an insulating film of oil. In this way benzine, heavy benzine, heavy motor benzine and benzol could be exploded in the cold machine. The average temperatures that must be maintained in the explosion chamber are about 400 deg. C. for petroleum, about 400 deg. for gas oil and about 375 deg. for coal tar oil. That it should be possible to obtain in his turbine complete combustion of these heavy oils which have been hitherto usable only in the Diesel engine, was an agreeable surprise to the experimenter.

With coal dust, on the contrary, the results were not encouraging. Samples from different sources were tried. Only

the extraordinary gaseous, but also very expensive cannel coal produced regular explosions, but only 20 per cent. of the coal dust admitted was exploded; the rest could not, in the short time available, "find" the necessary air.

Early Experiments with the Large Turbine

In the tests begun last year with the large turbine the fuel was power gas made from coke the poorest gas in hydrogen and in heat content which was used during the series of turbine tests. While the fundamental questions were quickly solved in the light of the tests with the small turbine, the striving after the greatest perfection, uniformity of operation, more certain control of the results and the preclusion of accidents offered unsuspected difficulties—solely because fundamental physical precedents were not available and in the present state of knowledge could not be known. After the better and more perfect installation of the same system of oil control, which on the first using was successful, the process became unstable, at first good, and then worse. The inventor had succeeded in running at 3000 r.p.m. without loads, but with excitation sufficient to generate 4000 volts, with only 250 to 300 cu. in. of gas per hour, corresponding to an indicated efficiency of over 20 per cent.; certainly an encouraging beginning so far as efficiency goes, but always only transitory as to practical operativeness. The average temperature corresponding to the deterioration of the process rose considerably above the value which at the highest should be reached by calculation. At one time the entire contents of the chamber would be exploded, so that the theoretically attainable height would be reached. Again, only a part of the mixture was burned in the chamber and the remainder apparently in the turbine casing, which, of course, was not designed therefor.

These observations all point to the foregoing fundamental data upon the influence of the temperature before ignition, as well as upon the explosion waves and the efficiency of the explosion. They led to the cooling of the walls of the explosion chambers by additional water, reducing the temperature to the lowest point which it was possible to obtain, and to the taking in of the air directly through the air valves from the outside. The performance thereby obtained was much more stable and smoother, without the introduction of any disadvantage. At the same time, a noticeable improvement in ignition was obtained, so that the ignition and explosion occurred as perfectly as could be expected, taking into consideration the variations in the specific heat, and entirely without explosion waves.

Future Development

The further development of the turbine, Mr. Holzwarth says, is a question of working out and developing the working process in the turbine proper so that the calculated capacity may be actually attained. What steps must be taken to effect this may be indicated by the following results of his experiments.

With light charges and small explosion pressures, the performance was satisfactorily near the calculated results; larger charges and higher explosion pressures did not produce the expected increase of capacity. The difficulty was traced, by process of elimination, to the nozzle proportion. With five chambers at work, the explosions were regular and in conformity with theoretical determinations. The experimentally determined values lie between the theoretical curve for complete explosion based on an initial temperature of 15 deg. and the curve calculated on the basis of an initial temperature of 100 deg. C. With 10 chambers at work, however, the explosion pressures were materially below the values obtained when 5 chambers were in operation. With explosions up to 4.2 atmospheres, absolute, the apparent capacity per chamber lies between the values which would be calculated for an initial temperature of 15 deg. C., and those for 100 deg. initial; above 4.2 atmospheres, absolute, the average experimental values lie outside of the calculated region, the actual results being smaller than the calculations.

Further investigation showed that in this condition the nozzles allowed the jets to escape with strong sound vibrations. The explanation for the favorable and unfavorable results of this phase of the experiments was that the gas was not fully expanded in the nozzles when the initial pressure was above 4.2 atmospheres, absolute, and the jet velocity notwithstanding the increase of pressure, did not increase as it should. The gas when leaving the exist of the nozzle had not been expanded to the pressure maintained by the exhauster, and caused very strong vibrations in front of it.

These pressure waves among other things, prevent the necessary free exist of the exhaust gases when 10 chambers are at work. It seems, therefore, that the nozzles are not proportioned for sufficient expansion, and that their proportions must be determined not by the formula used for steam-turbine nozzles but by the use of entropy diagrams for the gas turbine.

No mechanical injury of any kind—wearing, erosion, etc.—was developed in the slightest degree, notwithstanding the tests have continued altogether for some three years. Mr. Holzwarth attributes this exclusively to the fact that no water in any form is used in the process; air cooling makes the use of any water entirely unnecessary.

LETTER

Failure to Run with Normal Compression

The query of "J. M. J.," in Power of Dec. 5, as to why a gasoline engine running all right with the compression relief cock open will not run under full compression with the cock closed, brings to mind a recent experience in trouble hunting.

The engine concerned is a 10-hp. single-cylinder Otto engine using illuminating gas as fuel. It has make-and-break ignition, a hit-and-miss governor and is started by hand, first shifting an auxiliary cam into position to open the exhaust valve during a part of the compression stroke in order to relieve the compression enough to enable a man to turn the engine over for starting. The engine is an old one and usually very reliable.

Last spring, however, the engine began "going dead" on moderate loads, first missing irregularly and finally stopping entirely. The peculiar feature of the trouble was that after stopping still, it never refused to start at first trial, although it would stop again after running a short time. In time it was discovered that the stoppage could be prevented by shifting the cams into the starting position, when the condition described by "J. M. J." was exactly duplicated, namely, satisfactory operation on low compression and refusal to run at all when the compression was normal.

The trouble was located in the ignition plug, where it was found that oil had formed a shunt circuit through the insulating material, an asbestos washer. The resistance of this path was such that when the compression was low, enough current passed between the plug points to make an igniting spark, but when the compression was normal, the increased resistance between the separated points prevented a spark being formed there. This source of trouble is quite rare with the make-and-break ignition system, though frequently encountered with the jump-spark system.

G. M. Wesley.

La Fayette, Ind.

Considerable new equipment has been added recently to the laboratories of the College of Engineering at Northwestern University at Evanston, Ill. It includes small Corliss and high-speed engines, a steam condenser with engine-driven vacuum pump, a gas engine, a hydraulic ram, a centrifugal pump, a small 60-cycle generator, an oscillograph, an electric blueprint machine and other appliances.

A Self Contained Lubricator

Generally speaking, the more self-contained a piece of apparatus, the better, for there are less exposed parts to be

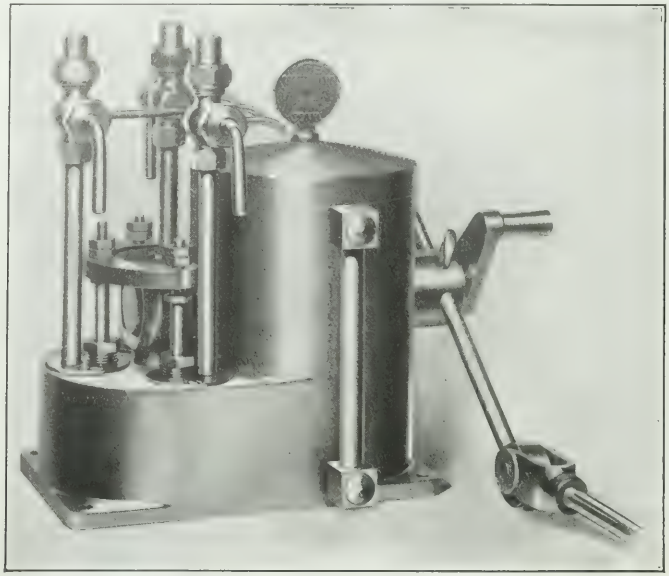


FIG. 1. THE IMPROVED STERLING MECHANICAL LUBRICATOR

interfered with and hence there is less danger of derangement.

The Improved Sterling mechanical lubricator, manufactured by the Sterling Machine Co., Norwich, Conn., and described herein, claims this feature. In Fig. 1, which is a view of a three-feed lubricator, it may be seen that there are no exposed gears, ratchet wheels or other similar parts, and the mechanism for operating the pump is contained in a recess in the oil reservoir.

The design and operation may be understood by referring to Fig. 2, which is a transverse section. The main operating shaft *A*, revolving in a journal formed in the casing of the reservoir, is driven by a set of four hardened-steel pawls which engage the steel ratchet wheel *B*. These pawls are carried in the hardened-steel driving hub *C* and are pressed against the face of the ratchet wheel by hardened springs as shown. The hub *C* is driven by the lever *D*, which is attached by means of a connecting-rod to some reciprocating part of the unit to be lubricated. The lever is fastened by means of the locking nut *E*, and hence it is a simple matter to vary the amount of rocking motion imparted to the shaft *C* by simply changing the effective length of the lever. A set of locking pawls *F* prevents any movement of the shaft *A* in the reverse direction.

The end of the shaft *A* projects beyond the casing and carries the cam *G* which operates the yoke *H*. This yoke drives the pump piston *I*. Attached to the yoke is a hollow shank which works in a hole in the main casing. This shank acts as a guide for the plungers, contains a felt wick and is filled with oil for lubricating the cam.

The action of the piston and double-ball valves is self-evident. There are two suction and two delivery valves in each pumping unit.

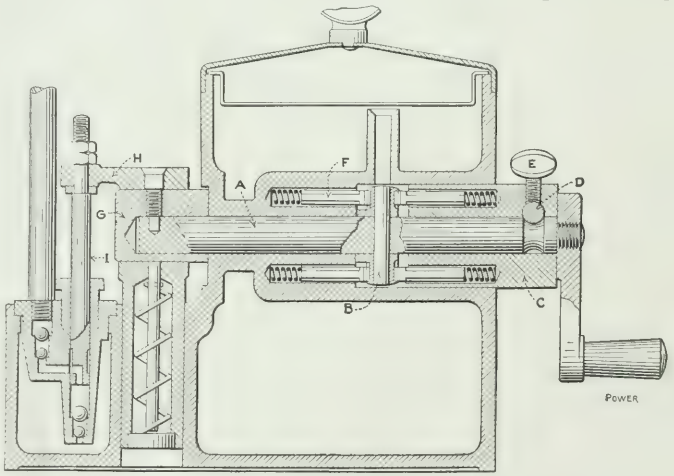


FIG. 2. SECTIONAL VIEW

Fig. 3 shows the delivery check valve and quill which may be used with this lubricator for dropping the oil into the center of the current of steam or air in the pipe leading to the part to be lubricated. The check valve has a double-ball check which allows the main check always to be covered with oil, thereby

FIG. 3. DELIVERY CHECK VALVE AND QUILL

eliminating any chance of corrosion by steam.

The points of superiority of this lubricator as set forth by its manufacturers may be summed up in the three words: simplicity, longevity and reliability.

Locomotive Boiler Explosion

While the Boston express train leaving that city at 4:30 p.m., and due in Syracuse at 2:45 a.m., on Jan. 26, was passing between Oneida and Wampsville, N. Y., the boiler of the engine exploded and the latter was completely wrecked. The engineer was instantly killed and it is believed that the fireman is fatally injured.

Up to the time of going to press the cause of the accident was unknown, but it is said that the water-supply pipe leading from the tender to the boiler may have become frozen because of the extreme cold, and that the injector therefore failed to force sufficient water into the boiler. As the thermometer registered 20 deg. below zero at Oneida on the night of the accident, it is also thought that the engineer's efforts to furnish heat for the passenger cars and still make his running time may have been a contributing cause.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

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Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

The Standard of Consulting Engineers

During the past few years numerous attempts have been made in New York State to force legislation compelling the licensing of consulting engineers. Whatever may have been the real motives behind them, one of the arguments advanced in support of the measure was that it would tend to raise the standard of consulting engineers and protect clients by preventing unqualified persons from practicing.

As is well known, all these attempts failed, chiefly because of certain provisions which made the measure inexpedient under existing conditions.

From recent advices, however, the members of the profession in England appear to have gone us one better; not by compulsory legislation, but by the establishment of an association of consulting engineers founded not only upon professional fitness but also upon a very high ethical standard.

The qualifications for membership state that a person must be a full member of the institute representing the particular branch of engineering which he practices; he must not in any way be connected with any firm with which he may have occasion to deal on behalf of clients, nor may he accept any commissions, discounts or other profits from any professional work upon which he is engaged, other than the fee from his client. Furthermore, he must not advertise or canvass for consulting work, act for a new client to the prejudice of an existing client, nor accept professional work in connection with which another member has been appointed, unless formally notified by the client of the termination of the former appointment. A disregard for any of these rules makes a member liable to expulsion from the society.

We do not know how large a membership the society has at present, nor do we venture a prophecy regarding its ultimate success. Its motives, however, are most commendable and it aims to lend dignity to the profession. Whether this can survive in the face of present commercial tendencies will be watched with utmost interest on both sides of the Atlantic.

Uniform Boiler Laws

It is stated that a determined effort will be made at the coming convention of the American Boiler Manufacturers Association at New Orleans, Mar. 12 to 15, to decide upon uniform boiler specifications, the adoption of which will be urged upon the legislatures of the various states of the Union and the provinces of Canada.

At present, there is a marked absence of any uniform rules regarding boilers in the several states. A few have laws which adequately cover both the construction and inspection of boilers; others provide only for the inspection and operation of the boilers, while the majority lack any state supervision over either the construction or operation of boilers, leaving the latter duty to the judgment of the particular district in which the boiler is located.

This condition of affairs is not only a menace to public safety but it is at times very embarrassing to the manufacturer A boiler made according to the standard specifications of a manufacturer doing business in one state may, if carried to another state, have its allowable working pressure considerably reduced because it does not conform strictly to the specifications as enforced in the second state. Nevertheless, the rules of the first state may represent just as sound, if not sounder, engineering judgment. One of the first steps in drawing up uniform specifications would be to eliminate such incongruities in the law.

Some have advocated placing the construction and inspection of stationary boilers under Federal control, pointing out the rigid supervision maintained in the case of marine boilers and the consequently small number of explosions in this service. While such a course might possess certain advantages it would be

contrary to the states' rights, but there is no reason why uniform state laws, rigidly enforced, should not accomplish the same result.

Nothing to Do

A glimpse into an average engine room will often disclose the engineer leaning out of the window, sitting at his desk, or standing apparently idle about the room. Doubtless, it is this seeming idleness that has influenced some men to take up engineering as an occupation when they have no particular qualifications for it.

The engineering field presents great possibilities for advancement; there are also many chances for failure. The successful engineer does not find it necessary to go about his work in dirty clothing and with hands and face looking like those of a coal passer nor habitually to work with his hands.

Most of these men who apparently have nothing to do have passed from the stage of engineering drudgery to positions which require executive skill rather than manual labor.

No engineer who has attained success has seen the day when he had nothing to do. Even when his plant is in such condition that it will operate with but minor repairs during the year, he finds enough to keep him busy. The engineer who keeps his plant in readiness to deliver the load when the demand is made has had enough to do to get his machinery into the pink of condition, and is entitled to lean out of the window when he can find the time.

So far as the plant goes, there may be nothing to do; the boilers may be in good order, the engine and auxiliaries may be running as smoothly as it is possible to have them run.

But the progressive engineer realizes that there is something for him to do even when all of these satisfactory conditions prevail. He knows that he must look into the why and wherefore of this or that device; that he must find time to read on the subjects relating to his work, and that there are hours to be spent in weighing the evidence for or against making certain changes about the plant. All of this requires time, and while the engineer is leaning out of the window or sitting in his chair he may be studying out a problem the solution of which may mean economy for his employer.

No man is employed so constantly as the real engineer, the man who does things. If there are engineers who have nothing to do, they are not making the best use of their opportunities, and if they sit and twirl their thumbs it will not be long before there will be an opening in their plants for men who can make good.

Care of Internal Combustion Engines

The successful operation of the internal-combustion engine as a prime mover for the generation of electric power is not dependent upon any extraordinary professional skill on the part of the operator but upon his ability to exercise a little common sense and his willingness to keep things clean and in good order.

Cleanliness is, perhaps, of first importance and due attention should be given to the cleaning of the cylinders, valves, exhaust piping, etc., at stated intervals, to be determined by the kind of fuel used. For instance, highly carbonaceous gases will require more attention to internal cleaning than those having a high content of hydrogen and nitrogen. In some cases the quality of the fuel will necessitate a thorough cleaning at least once a month while in others two or three months may elapse before this is necessary.

A sharp scraper should never be used in cleaning the internal working parts of an engine, such as the rubbing surfaces and valve seats. A liberal amount of kerosene oil and a wooden stick will usually remove all of the incrustation and deposit without scratching or impairing the wearing surfaces in any way. The engineer in charge should also pride himself upon the external appearance of his engine and a general wiping up once or twice a day is not too much in order to have things looking neat.

Very often when an engine is not working as satisfactorily as it might, the cause is assumed to be leaky valves, and they are immediately reground, using emery for the purpose. This is a mistake because usually the use of emery will result in overgrinding, which is not only useless but shortens the life of both the seat and the disk. Pulverized pumice stone mixed with a little oil will answer the purpose quite as well and will practically eliminate the liability to overgrinding.

The question of proper lubrication is also an important one, particularly as regards the cylinders. The intensely hot gases which come in contact with the lubricating oil have an evaporative effect and tend to thicken the oil, forming a gummy lining on the wall of the cylinder. It is therefore necessary that an oil be used which is particularly adapted to this severe heat and fed to the pistons and walls of the cylinders at the proper rate. Too much oil is just as harmful and expensive as not enough, for the excess oil will be blown through the exhaust valves and tend to clog up the passages. The cheaper grades of oil are always more costly in the end than the more expensive kinds. Sometimes a very small quantity of finely powdered graphite mixed with the oil gives good results and imparts a smooth and glossy surface to both the piston and the cylinder. The best engine oil obtainable is none too good for the other parts of the engine.

In starting a gas or gasoline engine it is well to remember a few facts regarding the explosive qualities of the fuel. The proportions of gas and air have their limits for explosive effect; therefore, a mixture too rich in gas will usually not give any better results than a gas that is too lean. A little practice and experience, however, will soon teach the operator as to the mixture that will produce the best results and he should then mark the mixing valve so that he will always know in the future how to set it when starting up. Great assistance could be given in this respect if every builder of combustion engines would furnish complete and definite instructions with each engine sent out and give some practical lessons to the man who is to operate it. Some builders have adopted the latter policy, with excellent results; it should be general, however.

New York City has experienced another boiler explosion, the second within a few weeks. Both boilers were located under the sidewalk.

The new boiler-inspection department of New York City can do good work in cleaning out some of the old boilers now being operated in that city. No use waiting until they explode.

Readers with Something to Say

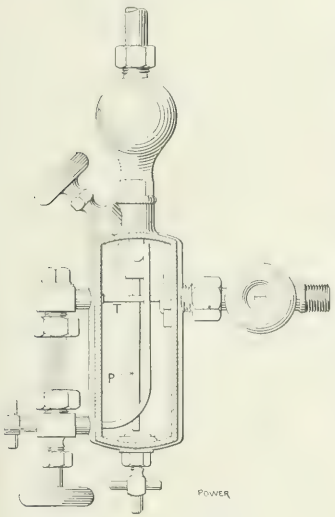
A letter good enough to print will be paid for. Ideas, not mere words, wanted

Lubricator Experience

The majority of engineers have had experience with sight-feed hydrostatic-condensing lubricators, and had the sight-feed glass fill with oil. There may be several reasons for this, but I have discovered what I believe to be the most common and likely of all.

I used to think that a stoppage in the oil-outlet passage of the lubricator was what caused it, but I found that this would simply stop the feeding, so I had to search in another direction.

I got the manufacturer's lubricator



SECTIONAL VIEW, SHOWING DESIGN OF LUBRICATOR

catalog, studied the descriptions and directions carefully, and I soon got a fairly clear idea of the construction of the lubricator from a sectional cut, the one herewith shown.

Referring to the cut, *P* is a tube through which water from the condenser above enters the body and takes the place of the oil as it passes out through the curved tube. The oil enters the upper end of this tube and is forced downward through it by the pressure of the water. The oil then passes in drops up through the sight-feed glass, and across the upper end of the body through the horizontal tube *T*. The tube *T* discharges the oil into a heater, a vertical cavity formed on the inside of the body at the oil-feed outlet, as shown.

From the heater the oil passes out through the discharge shank and into the steam pipe or steam chest of the engine.

The heater described has dry steam in it when the lubricator is working, the oil and the water of condensation passing out at the discharge shank as fast as any accumulates. When first filling the lubricator and before starting the feed of oil, time should be allowed for the condenser and sight-feed glass to fill with water.

The water that fills the glass is formed from the steam condensing that enters from the heater through the horizontal tube *T*. After the glass has filled with water and oil is being fed in drops through it, the outgoing oil fills the tube *T*, thus preventing any more steam from getting into the sight-feed glass while the feeding continues. It can readily be seen that if any water in the glass at the time the feed is started is allowed to escape, no more water will get in to take its place, and therefore the incoming drops of oil will replace it.

If water leaks out around the packing-nuts of the sight-feed glass, or around the oil-regulating valve stem or gets past the drain plug, the result will be that the oil will take its place and will fill the glass from the top downward as the water escapes. Of course, when the glass fills with oil it is necessary to stop the feed and blow it out clean and let it fill with water before restarting the feed.

L. J. WATSON.

Port Huron, Mich.

Baffler Plug Caused Pound

Recently I took charge of a turbine station in which one of the turbines vibrated quite badly; a pounding noise could be heard in the vicinity of the step bearing.

The carbon packing was in need of repair and it was thought that this might have something to do with the pounding. When the packing was repaired and no improvement was observed, it was thought that the guide bearing might be loose in the holder but it was found to be all right.

We measured the flow from the step bearing and the amount was ample for this type of turbine, but it was observed that the flow came in squirts instead of a steady stream; this was our cue. We inspected the baffler plug, found that it had been sawed off and did not fill the barrel by 4 inches, and that it worked back and forth with the stroke of the step pump, thus causing the step blocks to grind.

A hole was drilled in the plug and tapped for a machine bolt, and the length was adjusted to prevent any movement of the plug.

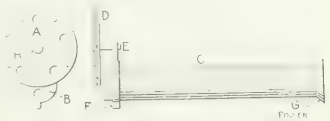
This cured all of the pounding noise and the trouble in the turbine.

WILLIAM BLACK.

Punxsutawney, Penn.

Home Made Smoke Tintometer

The home-made tintometer shown in the accompanying figure can be made by any engineer for a few cents and a little labor. The part *C* is a piece of tube (brass, tin, or iron) about 10 in. long. An eye-piece is formed by flaring out the end a little as at *G*. At the other end a piece is fitted and soldered on with two holes in it as at *B*. Two pieces like *A*



HOME-MADE SMOKE TINTOMETER

are cut with five holes in each, as shown, the holes to be of the same size as those in *B*. Four of the holes are glazed with pieces of tinted glass corresponding to the standard tints in some reliable smoke scale, any optician will supply the pieces for a few cents; the fifth hole remains empty. The glass is held in place by putting the two covers together and clamping them with four small bolts. A strap *F* is placed at the end of the tube and the tint case fastened so that it will revolve as shown at *D*.

The instructions for the use of this instrument are as follows: When examining the smoke from a chimney the observer turns the instrument so that the aperture, which is fitted with the revolving diaphragm, looks toward the windward side of the smoke; through this aperture he sees past the side of the smoke to the clear light of the sky beyond, the same light which is illuminating the smoke column.

Through the other aperture the observer sees at the same moment a circular patch which appears to be cut out of the column of smoke as it issues from the stack.

All that the observer has now to do is to revolve the diaphragm until both

pertures appear to have equal illumination, and a glance at the numbered glass will show in an instant if smoke is light gray," "dark gray," "black," etc., according to the number on the smoke scale.

JAMES E. NOBLE.

Toronto, Ont.

Scale

The pile of scale shown in the accompanying picture is a four months' collection from a 60-hp. return-tubular boiler. Perhaps many engineers who do not have bad water to contend with do not know how fortunate they really are. This picture may serve to show them.

A FOUR-MONTHS' COLLECTION OF SCALE FROM ONE BOILER

A. A. DEVER.

St. Cloud, Fla.

Value of Engineering Journal

A full appreciation of the value of engineering journals and magazines can be obtained from a study of their purpose. Because a long article describing the products or manufacturing process of some company is sometimes published, it is occasionally thought that the object of the paper is advertising. But the real aim of most engineering papers is to furnish a medium through which useful and interesting knowledge belonging to the profession may be made public.

Most engineering practice is empirical. The degree of success of a project may be predicted with considerable accuracy if a similar scheme has met with success a number of times previously. This is the reason why the consulting engineer's office contains a reference library largely made up of current engineering literature. Here the engineering journal is of great value. It may be of value to the student in a similar way if the important and interesting articles are taken care of in some systematic manner.

The engineering profession at large would be extremely fortunate if it could believe all the statements made in its current literature. The fact that misstatements are made is not always the fault of the paper; sometimes it is. It is needless to say that a paper whose articles cannot be relied upon is worthless. It is well to avoid those papers which appeal to the popular imagination as, in order to make glowing statements, the truth is often distorted beyond recognition. Herein lies the strong point of the strictly engineering article; facts are set forth in the fewest possible words consistent with clear meaning, and rightly so, for the simple statement is worth the most.

One cannot read all the papers belonging to his chosen branch of the profession; he cannot carry too much ballast, else he sink. To get the most from his reading—for, after all, the benefit derived therefrom depends upon himself—he should read the best articles in the best papers treating of his branch of engineering, and read them thoroughly.

J. A. M. ROBINSON.

Chicago, Ill.

Repairing Boilers by the Welding Process

In a horizontal return-tubular boiler the rear head was so badly corroded and wasted away around the handhole that the inspector ordered a reinforcing piece to be put in. After the head had been cut away until only plate of full thickness remained, the reinforcing piece was slipped inside and four rivets, as shown in Fig. 1, were put in. The cutting of the head and of the handhole in the reinforcing piece was done with an oxyacetylene flame. The plate was then welded on the line indicated in the sketch and steel was welded over the rivets. I could not understand why the inspector ordered the rivets put in, as all of the strains are of compression, there being no part in tension. The boiler is under steam at the present time and is perfectly tight.

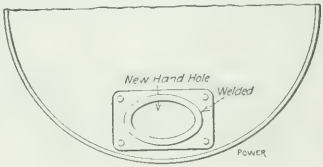


FIG. 1. REINFORCED HANDHOLE

Of a battery of seven Manning boilers, six were wasted away on the fire side of the furnace sheet so that it was deemed necessary to either cut out the sheet, part of the way around, for about 60 in. long by 8 in. high, or to build up the sheet by the oxyacetylene welding process. After carefully looking the matter up it was decided to try the welding. The metal to be added varied from ⅛ in. in thickness down to nothing and the area was about like that shown in Fig. 2.

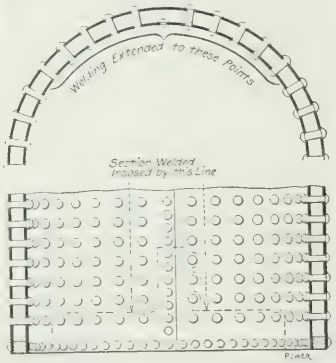


FIG. 2. WELD APPLIED TO MANNING BOILER

The reason for running up the vertical seam as shown in the figure was that the outside sheet had been trimmed so close to the rivets to get a calking edge that it was impossible to make the calking hold for any length of time.

The heads of the rivets in the bottom ring and the lower row of stay-bolts were welded over, as were the rivet heads at the vertical seam. The sheet around the bottom ring had to be built up below the rivets so as to get a calking edge.

Under hydrostatic test, six stay-bolts were found broken, probably due to expansion and contraction strains; also the fatigue of the metal must be taken into consideration as the stay-bolts had been in about 16 years. The advisability of welding the vertical seam is questionable, it being a lap joint, and expansion and contraction cracked the weld in places, necessitating the cutting away of the welded edge and calking of the joint. The welding of the fire-cracks around the door was successful.

It is evident that welding reduces the cost of repairs more than one-third and does away with the possible, and probable, future trouble with the extra seam in the furnace sheet had the work been done by cutting out the defective sheet and putting on a patch. Also, it was not necessary to move the boilers from their positions, a portion of the base plate, the grates and part of the outer covering being all that it was necessary to remove.

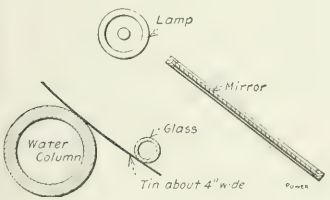
F. R. PRATT.

Adams, Mass.

Water Gage Illuminator

The accompanying figure is a plan view of the way in which I arranged a mirror and an electric light so as to make the height of water in the gage-glass distinctly visible from a distance as great as 65 ft.

I first took a piece of tin about 4 in. wide and as long as the glass itself. After whitewashing this on one side I



ARRANGEMENT OF LIGHT AND MIRROR

fitted it between the water column and the glass at the angle shown in the figure. I then hung a lamp and a mirror in the positions shown. The angle of the mirror is such that the height of the water can be seen from any point in the boiler room, either directly in the glass or indirectly in the mirror.

The empty glass forms a dark strip against the white background of tin, while the water shows up brightly and distinctly.

E. T. LEHMAN.

Chicago, Ill.

Noisy Heater

I have in my charge a Stilwell-Bierce heater. When I took charge of the plant the heater was used as a closed heater, but I soon found that the coils in it were not sufficient to heat the water to the desired temperature. The company would not buy any more coils so I decided to take out the coils and run the heater open.

The feed to the heater emptied in an overflow pan 10 inches below the baffle plate at the top and about 4 inches in front of the upper exhaust inlet. The first night I found that the feed water was as hot as it could be pumped and the heater did not make any noise. When I came on watch the next day at 12 o'clock I could hear a faint noise in the vent pipe of the heater. During the day there is but little load as most of the current is used for lighting, and we run only a 60-horsepower high-speed engine until evening. When I started up for the peak load with the 16x30-inch Corliss, one would think that there was a gas engine concealed in the heater.

I opened the heater and tried to find something loose inside but could not. I then fed the water on the top of the baffle plate and let it sprinkle through the exhaust steam. This did not help the noise. I then put in a bypass for the water from the boiler-feed line to the heater feeder. This helped some. The noise is not so loud and it is more regular; formerly it was intermittent like the exhaust of a gas engine. I never heard of a heater making a noise like this. If anybody has had this trouble I would be glad to hear how it was overcome.

L. C. GREENE.

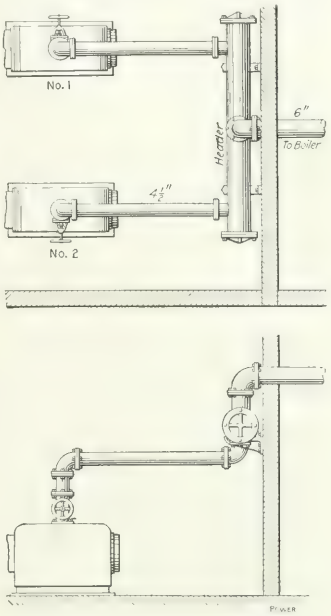
Gallipolis, Ohio.

Steam Pipe Vibration

It was my first shift in a new plant which consisted of two boilers and two Corliss engines belted to a direct-current generator. The engines were supposed to run at the same speed and were piped as shown in the accompanying figure.

No. 1 engine had been running alone all day as the load was light, but about 4:30 o'clock the night load started to come on and so I started up No. 2. Everything went along nicely for about 15 or 20 min., when the header and steam pipes began to vibrate in a manner that shook the whole building. This continued for about 5 min., when things settled down to quiet running again for nearly half an hour. Then, the vibration was repeated. As the pipe started to thump for the third time, I glanced at the valve-gear of the two engines, and the cause of the vibrations was a mystery no longer. The valve-gears of the two engines were in step or synchronized.

The steam header was so small that it could not supply steam to both cylinders at exactly the same moment without a drop in pressure. Therefore, just as the two engines got in step the header started to vibrate. I partly overcame the



PLAN AND ELEVATION, SHOWING PIPING

trouble by placing large separators close to the throttle valves of the engines, which should have been done when the engines were installed.

CHARLES FENWICK.

Wapella, Sask.

Sperm Oil for Cylinder Lubrication

I would like suggestions from POWER readers regarding cylinder lubrication. In the plant where I am employed it is necessary to use an oil that will not stain the goods, as exhaust steam is used to boil the water in which the goods are placed in the process of manufacture.

I am using sperm oil for cylinder lubrication in 15 high-speed engines which run at a speed of from 125 to 225 r.p.m., the cylinders ranging from 12 to 36 in. in diameter. This oil does not lubricate them unless I feed from 2 to 4 quarts of oil per day per engine, which comes heavy on my operating expenses.

Have any POWER engineers had experience with sperm oil as a cylinder lubricant, and have they any suggestions to offer as a substitute lubricant to meet my conditions?

J. BLACKNER.

Lowell, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

A Commercial Water Power Problem

The criticisms in the Jan. 9 issue of Prof. Ennis' article on the above subject, which appeared in the Nov. 14 issue, excited my interest, and I wish to criticize it still further.

In determining the value of a water power it is necessary at all times to consider under what conditions and at what cost the power can be generated, because it is on the cost of power generated by other methods in the plant that the value of water power depends. For instance, if a plant like the one under discussion has water power solely to help out its main engines which are of large capacity and, therefore, can be made to generate power at low cost, the comparison should be made upon what it costs to produce power by means of these engines when they are in such condition as they would naturally be put if the plant owner were using every possible means to operate the plant at the lowest possible cost.

It is evident from reading Prof. Ennis' article that the owners were operating an uneconomical plant and were making no attempt to improve it. An evaporation of 5 lb. of water per pound of coal should not be tolerated in a plant of approximately 2000 hp., and it shows a lack of energy somewhere as well as of commercial power conditions. Prof. Ennis figured that the coal costs 0.6875c. per horsepower-hour, representing a total coal cost, on the basis of 2000 hp. for 6000 hr. per year, of $82,500. He further says that a conservative allowance for labor and supplies would make the operating cost approximately 1c. per horsepower-hour. This figures to 0.3125c. per horsepower-hour, or $37,500 per year for these items alone, making the total cost of power, exclusive of fixed charges, $120,000 per year.

I question this allowance for labor and supplies. A conservative allowance for labor and supplies per day in a plant of 2000 hp., operating 20 hr. per day, is $28, with two watches of 10 hr. each. This amounts to 0.07c. per horespower-hour, or $8400 per year. If the coal bill is correct, the total operating cost should be $90,900 per year, which is equivalent to $45.45 per horsepower-year, exclusive of fixed charges, instead of $60.

If, now, the plant be put into proper operating condition and it be assumed that the coal is of good quality, 3 lb. per horsepower-hour should operate the engines, particularly as they are operated 20 hr. out of the 24, and, therefore, the standby losses must be small. Then, under these conditions the coal cost would be $49,500 and the labor, as before, $8400, although this is a little large, because with a reduction in the amount of coal used, the labor would naturally fall off somewhat. We will neglect this and assume the total operating cost to be $57,900 per year, which is equivalent to $28.95 per horsepower-year. It might, however, be worth while in this plant, as it is pretty badly out of shape, to rebuild it entirely, allowing $9 per horsepower-year for fixed charges on the rebuilding, which is a liberal estimate. This would bring the power cost up to $37.95 per horsepower-year.

The introduction of a condenser might save an additional half pound of coal per horsepower-hour and thus reduce the coal bill by $8250, bringing the total operating cost down to $49,650, which is equivalent to $24.83 per horsepower-year.

Figuring with Prof. Ennis on the same basis and neglecting the fixed charges on the water power, and, therefore, on the steam plant, the cost of 60.3 hp. developed from the stream would represent a yearly value of $1497.25. Capitalized at 6 per cent., this would represent $24,954.

If the fixed charge on the steam plant of $9.90 per horsepower-year is taken into account, to cover the condenser in addition to the main plant, the total cost would be $34.73 per horsepower-year.

Since the development of a water power ordinarily demands a considerable expenditure for dam, head gates, canal or penstock, etc., an estimate of $125 per horsepower is not excessive; it would fairly represent a cost of $12.50 as a fixed charge against the water power, including interest, maintenance, depreciation, taxes, etc. This subtracted from $34.73 would leave a relative value for the water power of $22.23 per horsepower-year or a total of $1340, which, capitalized at 6 per cent., would represent a value of $22,333, instead of the minimum value of $25,000 put upon it by Prof. Ennis.

I have assumed that under these conditions the plant is so located that the water runs from the head gates directly through the condenser and therefore no pumping is required. Also, the water required to condense the steam from this plant I have estimated would not exceed 1 cu.ft. per second; this is a liberal allowance. Then, there would be 23.07 cu.ft. per second left available for power purposes.

These figures indicate that the company could not afford to pay more than $1340 for the use of the water power. It is evident also that this value also represents the lease value; that is, the maximum price which the company could afford to pay for this water would be $22,381.

If there was any use for exhaust steam—which Prof. Ennis has neglected to state—and in large quantities, it might be that the power cost would be materially reduced from the figures here given. If this heat were not available from the exhaust steam of the engines, it would have to be supplied in some other way. Therefore, so long as a portion of it is available from the exhaust steam of the engines, the heat which still is required can readily be calculated and the coal necessary to produce it subtracted from the coal required for power, thus making a considerable reduction in cost. This affects the steam-power cost and the value of the water power.

As far as plant improvement is concerned, it is warranted, and that makes it unnecessary to pay an exorbitant price for water.

As regards the necessity of higher-priced attendants in the event of the installation of a condenser, there seems no reasonable ground for expecting that they would be needed. An engineer who is capable of handling a 2000-hp. noncondensing plant should certainly be capable of taking care of a condenser in addition, as the operation of a condenser requires no more experience than does that of an engine.

As a rule, it may be stated that the value of a water power is dependent, first, on its location; second, upon its reliability as regards continuity of stream flow, and, third, upon its size.

Considering item No. 1, a water power may be found which, while of considerable size and having potential value in its power, will be of no commercial value, as it is located too far from means of transportation in securing labor, supplies and the handling of finished products.

As to reliability, it is entirely a question of whether at minimum flow the water power is sufficient to supply all of the power required to operate the plant. If not, an auxiliary steam plant must be secured; and then the question arises, is it cheaper to utilize the water power with the additional steam power required and sacrifice a good location, or is it cheaper to develop a steam plant only and sacrifice the water for an advantageous location?

The third item is practically an extension of the second. The questions to settle in this case are: is the water power equal to the maximum demand that the mill is likely to reach? If not, is the saving during the time the plant is in operation by water power likely to be enough to offset the cost when the mill demands finally exceed the capacity of the water power and must be supplied by steam in addition to the water?

For any comparisons as to the value of water or steam, it is essential that the fixed charges be considered, as in many cases, especially on water plants, they are very heavy.

HENRY D. JACKSON.

Boston, Mass.

The following suggestions may serve to clear up the discussion by Messrs. Steely and Daugherty (in the Jan. 9 issue) and by H. D. Jackson, in the present issue, of my paper on "A Commercial Water Power Problem," in the issue of Nov. 14.

I fully agree that the value $41.45 per horsepower per year applies under the stated conditions only, and that the value of a water power in general depends entirely on local conditions. (See my book, "Works Management," pages 171 to 173.) This is an elementary principle, no doubt familiar to most readers of POWER. In undertaking to question the coal consumption and miscellaneous operating costs given in the paper, and in disregarding the remarks made therein in connection with "Improvement of Plant," it appears that at least one of the correspondents has lost sight of it.

It is not true that the power owners "cannot claim the water after it has gone below the dam." This depends on local arrangements. In the plant in question, the tailrace was a headrace for several mills at a lower level. Permission could not be obtained to pump therefrom.

The "roundabout method" for finding the mean head at the orifice which Mr. Daugherty criticizes was adopted in order to develop the arithmetical result without recourse to a formula for the proof of which a knowledge of calculus is necessary. It is roundabout, and to a mathematician unnecessarily so; but it is a method which every reader can understand. That is why it was used.

The only modification of statement which seems necessary is in connection with the remark that "the plant ran steadily." By this is meant not that there was a constant load of 2000 hp. for 6000 hours per year, but that during this time the load never fell below 60.3 hp. This might have been inferred from the context, but Mr. Jackson seems to have based certain objections on a different inference.

There was no intention of conveying the impression of great accuracy. Certainly it can only be said that the velocity is "about" 24 ft.—with an error possibly either way. It is best, however, to carry out arithmetical results a little beyond the limits of probable exactness in order not to add an unnecessary error of computation to those inherent in the assumptions.

WILLIAM D. ENNIS.

Brooklyn, N. Y.

Arrangement for Marking Keyways

I have been very much interested in the different articles in POWER showing how to mark keyways in Corliss valve stems. I will not criticize any of them, although I will still use my own rig for doing the marking.

It consists of a piece of iron with a

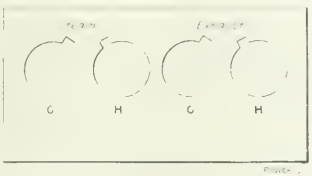


FIG. 1. PLATE FOR MARKING KEYWAYS

hole in it to fit the arm end of each stem. I put the stem in the proper hole and lay the T-end on a piece of bar of the right size to make the stem lie level. Then, I put the key in the keyway in the hole and mark the stem.

By this method I can get the stem all cut so that when I get the old stem out the new one is ready to put in to stay. I never have to change the valve rods.

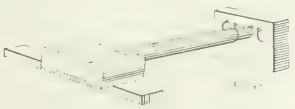


FIG. 2. SHOWING PLATES IN USE

Fig. 1 shows the way the face of the plate looks. I have one plate for each cylinder. Fig. 2 shows how I use the plate. It should lie on some level surface while the marking is being done.

F. W. BAIR.

Hancock, Mich.

Timely Discovery of Serious Lap Crack

I wish to make a correction to my article, "Timely Discovery of Serious Lap Crack," in the Jan. 2 number, in regard to the statement to the effect that Mr. Dennihan shut down in opposition to the wishes of the owner, who wanted to run until noon.

The owner, Mr. Cook, informs me that he was notified over the telephone that the boiler was leaking badly and that the engineer wished to shut down. Mr. Cook immediately gave orders to lower the pressure, and the shop was run for this purpose until the pressure was lowered. Mr. Cook also states that he ordered the boiler to be filled with cold water in order to lower the pressure more quickly.

LESTER A. FITTS.

West Fitchburg, Mass.

Responsibility for Defective Work

In the Dec. 26 issue, W. G. Walters describes the plugging and concealing of a wrongly drilled tube-hole in a return-tubular boiler head. I once had a similar experience, but, although the responsibility was traced to a man in the shop, he suffered no inconvenience other than a reprimand.

In this shop motor cars to run on railroad tracks were made. The wheels were put on the axles with a taper fit and pulled home with a retaining nut. The erectors received the axles and wheels from the machine shop, and when they were assembled, many of them failed to come up to gage. If too wide, they were reamed out; when too narrow, a piece of paper wrapped around the taper helped out wonderfully.

It made a very poor job, but the inspectors and testers frequently saw it done, the erecting foreman knew of the practice and I have an idea that the general foreman knew enough about it not to be over-inquisitive.

No complaint was made until the superintendent, in attending a convention, undertook to demonstrate one of the cars. In the course of the demonstration he pulled off a wheel to show what nice work was done in his shops. I do not know what else happened at that demonstration, but a day or so later the superintendent appeared in the shop with blood in his eye.

As in Mr. Walters' case, the trouble was traced to an erector, who took his calldown in a mild way, and a short time later was granted a raise in wages. Whether there was any connection between the two is hard to state.

One man may have improperly drilled the head, but it seems peculiar that he could tap, plug, chip, file and paint it

too before the tubes were put in without anyone being the wiser. Of course, in a small shop, with one man completing the boiler himself, this might have happened, but in a shop small enough for this it seems probable the foreman would have smelled a rat.

This is not written to discredit Mr. Walters' story in any way. In reading it I assumed from the tone of the letter that the author was connected with the buyers and not the manufacturers of the boiler, and that the latter would, of course, place the blame on the little fellow, just as the man killed in the boiler explosion is generally found to be to blame.

JOHN BAILEY.

Milwaukee, Wis.

Pipe Flange Bolting

I was much interested in the editorial in the Dec. 26 issue of POWER on the above subject, and agree with the writer, but I do not think that he carried the subject far enough.

In speaking of the man in the drafting room being responsible for the tap and stud instead of the through bolt, would it not be a good idea if this same man would also lay out the work so that all bolts and nuts could be reached?

How often one sees a case where for about half of the way around the pipe one cannot get the same leverage on the nuts as on the balance of them. When this is the case, it is almost sure that the nuts which are easy to get at are pulled up tighter than the others; therefore, an unequal strain on the flange is produced which in time is bound to cause a leak.

C. L. JOHNSON.

Newark, N. J.

Correction

There is a mistake in the printing of the formula for length of belt given by William Hirst in the issue of Jan. 9.

Twice the length of the hypotenuse is

$$2\sqrt{(R-r)^2+D^2}$$

The approximate formula on page 1125 of my "Pocketbook" (eighth edition) gives a more nearly correct result than Mr. Hirst's formula. Using his notation it is

$$L = 2D + \pi(R+r) + \frac{(R-r)^2}{D}$$

WILLIAM KENT.

Montclair, N. J.

In looking over the formula in Mr. Hirst's letter in the Jan. 9 issue, I found that apparently he had made a mistake in stating it.

The formula which I use, and probably the one which he intended to state, is

$$2\sqrt{(R-r)^2+D^2}+(R+r)3.1416=L$$

The result obtained by this formula is exactly the same as the answer given by Mr. Hirst. Thus it is quite clear that his mistake was simply in writing out the formula.

VICTOR JUMP.

Caledonia, Ohio.

Leaky Corliss Valves

In two recent issues of POWER there appear comments on leaky valves on Corliss engines. I agree with the writer who says that they are rarely ever tight. As a result of close observance for 25 years, covering hundreds of examples, I have found that engines working under 80 or 90 lb. steam pressure that have previously been carefully fitted will be found reasonably tight; but when 150 lb. pressure is carried they tend to leak badly. Some horrible examples have been found in engines fresh from the shops of even the most reputable builders. Thus it appears that temperature has much to do with the matter for large temperature variations combined with heavy pressure change the form of the cylinder casting and valve seat.

The remedy is to do as one writer suggested: File the high spots, making frequent examinations until a fit is obtained and the contact surfaces of both valve and seat are uniformly bright. This writer suggests draw filing the high spots, but I have found that the average workman is afraid of doing anything. Many times I have taken the roughest bastard file I could buy and "razeed" the valve ends; often I have done this a second time after a day's run, and even a third time. When the valve began to show bright in the middle of its length, I would finish up with a good "mill-saw" file, filing around—not draw filing.

One writer mentions making the steam valves a "trifle smaller than the bore," thus allowing them to lift in case of water in the cylinder, etc. This idea is correct, but the method is wrong. The valve should be turned to fit the bore, but the top half of the circle on the ends should be cored away not less than $\frac{1}{16}$ in. on a 5-in. valve. This will be hard for the lathe man to caliper for size, but a small lug or rib can be left on top from which to caliper, and be cut away after the valve is turned up. This form is a great safeguard against damage by water.

I have seen many valves broken in the middle by water while no great damage was done to the engine elsewhere, and if the valve could have lifted, the distress might have been passed without damage. This form of valve will be likely to have a "click" if compression is run up to or near the initial pressure; the remedy is not to run the compression so high.

W. V. WHITE.

Cincinnati, Ohio.

Brick for Boiler Walls

In discussing Lewis L. Scheiderer's suggestion of using hollow brick for boiler walls, as printed in the issue of Jan. 9, I would say that while I have not had experience with such brick I would not deem it of any merit, as recent experiments with boiler walls, with and without air space, show conclusively I believe that a solid-brick wall is the better insulator of heat. If this is true, the rule would likewise apply to walls built of hollow bricks, and to a far greater degree.

VICTOR BONN.

New York City.

Induction Heater

In a short paragraph in the issue of Jan. 9, on the page of "Inquiries of General Interest," under the title, "Induction Heater," we would like to call attention to the last sentence, which states that "induction heaters are used in places where it is not convenient to place a thoroughfare heater." We criticize this to the extent of saying that the question of convenience is the least often brought up in arguments concerning the merits of thoroughfare vs. induction heaters. It is usually a question of economy and safety. The induction heater is capable of being connected up in a less expensive manner and as no bypass is necessary there is no possibility of damaging the heater through a misuse of the valves in the bypass.

There are also other reasons for the use of the induction heater which might briefly be mentioned as follows: (1) the steam does not pass through the heater body before going to the heating system or the atmosphere and therefore does not become water-soaked in passing through the spray chamber of the heater; (2) there is no possibility of exceeding the capacity of the oil separator when additional steam units are turned into the main exhaust line, and (3) the induction heater is the only one which can be arranged so as to reduce back pressure.

WARREN WEBSTER & CO.

Camden, N. J.

Our contemporary, *Engineering News*, expresses the belief that it would be a most useful thing to engineers in this country if the Bureau of Mines, which has already made a detailed study of the operation of several kinds of power generators, should collect and publish a body of facts on the operating costs for medium-sized steam-engine plants.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Power Required for Compressing Air

How much air can be compressed per minute to 225 lb. gage pressure in a compressor driven by a 3-hp. engine?

A. D. M.

Assuming the initial pressure in the cylinder to be 2090 lb. per square foot, the compression of 1 cu.ft. of free air per minute to 239.7 lb. per square inch, or 34,516.3 lb. per square foot, will require 0.2743 hp. With an overall efficiency of 80 per cent., this would mean

$$\frac{0.2743}{0.8} = 0.343 \; i.hp.$$

to be delivered by the steam end. Thus three horsepower under these conditions will compress

$$\frac{3}{0.343} = 8.746 \; cu.ft.$$

of free air per minute.

Power Factor of a Feeder

How is the power factor of a feeder found when the branch circuits have different power factors?

G. G.

The power factor of the feeder is the reciprocal of the square root of 1 plus the square of the quotient of the sum of the product of the current and the inductance factor of each branch circuit divided by the sum of the product of the current and power factor of each circuit. Expressed as a formula, the rule would be as follows:

$$p = \frac{1}{\sqrt{1 + \left(\frac{I_1 q_1 + I_2 q_2 + I_3 q_3}{I_1 p_1 + I_2 p_2 + I_3 p_3}\right)^2}}$$

p = Power factor of the feeder;
I = Current of each branch circuit;
$q_{(1,2,3)}$ = Inductance factor of each branch circuit;
$p_{(1,2,3)}$ = Power factor of each circuit.

Putnam Engine Valves

Why is more lead given to the head-end than to the crank-end valve of a Putnam engine?

L. P.

Owing to the angle which the connecting-rod makes with the center line of the engine, the piston travels faster when leaving the head end than the crank end of the cylinder, and more lead is given to the head-end valve to insure full pressure on the piston at the beginning of the stroke.

Taking Ammonia Out of the System

How can the ammonia be taken out of a compression ice-plant system without losing any of it?

P. McD.

If the plant is of ordinary construction and design, connect an empty shipping tank to the bottom connection of the liquid-ammonia receiver; have the tank on a scale and weigh the amount of ammonia put in; do not allow more ammonia to enter the tank than it originally contained when shipped; that is, not more than five-eighths of its cubic contents. The chances are about even that, unless a man is thoroughly familiar with the above operation, he will burst the compressor, or blow up the receiving tank and possibly lose his life.

Flow of Steam in a Pipe

What amount of steam will flow through a 4-in. pipe 100 ft. long, the initial pressure being 80 lb. and the terminal pressure 38 lb.?

G. F.

Divide 3.6 by the diameter in inches; add one to the quotent, and multiply the sum by the length of the pipe in feet. Call this product 1. Then multiply the difference between the initial and the terminal pressures by the fifth power of the diameter and by the density of the initial pressure. Call this product 2. Divide product 1 by product 2 and multiply the square root of the quotient by 87. The density of the steam at 80 lb. is 0.2151. Applying figures to the rule, it would be expressed thus:

$$\sqrt{\frac{0.2125 \times (80 - 38) \times 4^5}{100\left(1 + \frac{3.6}{4}\right)}} \times 87 =$$

$$\sqrt{\frac{0.2125 \times 42 \times 1024}{100 \times 1.9}} \times 87 =$$

$$\sqrt{\frac{9139.2}{190}} \times 87 = 1\sqrt{48} \times 87 =$$

$$6.9282 \times 87 = 602.75 \; lb. \; per \; min.$$

Efficiency of a Condensing Engine

How does the extra power of the vacuum make a condensing engine more efficient?

P. J. O.

The vacuum in a condenser is not a power, yet it occupies the anomalous position of increasing by its pressure the capacity of the engine for doing work. This is because the atmospheric pressure or resistance which is always ahead of the piston in a noncondensing engine is, in a condensing engine, removed to a degree corresponding to the height of the vacuum, and makes available just so much more of the pressure behind the piston. If there is an average pressure of 40 lb. behind the piston and a vacuum of 26 in. is maintained in the condenser, there will be 13 lb. of resistance removed from the front of the piston, thereby making available 40 + 13 = 53 lb. per square inch.

Weight of the Flywheel

How is the weight of a flywheel found?

A. M.

Requirements and conditions differ so materially that it is difficult to give a general rule; different kinds of work will admit more or less variation. A rule to determine the weight is: Multiply the area of the piston in square inches by the stroke in feet and by 12,000,000 for average work. Divide this product by the square of the number of revolutions per minute multiplied by the square of the diameter of the wheel in feet. The quotient will be the required weight of the rim in pounds. Assume an engine of 20-in. cylinder diameter, 48-in. stroke, 75 r.p.m. and the flywheel 20 ft. in diameter. Using figures, the rule would be expressed:

$$\frac{314.16 \times 4 \times 12{,}000{,}000}{75^2 \times 20^2} = \frac{15{,}078{,}680{,}000}{2{,}250{,}000}$$

$$= 6701.6 \; lb. \text{ or } 3.35 \; tons$$

The constant will range from 10,000,000 for light-service engines to 15,000,000 for engines driving generators.

Low and High Speed Engines

What advantage has a low-speed over a high-speed engine?

E. D. G.

The low-speed engine, especially the four-valve engine, is usually more economical of steam than the single-valve high-speed engine, because its heat losses through the cylinder walls and its friction are less in proportion to the amount of steam used on account of the greater cylinder volume of the low-speed engine.

Water Power Valuation on a State Line

An interesting example of the complications sometimes occurring in water-power valuation is illustrated by a recent decision of the Massachusetts Supreme Court in the case of the Blackstone Manufacturing Co. vs. Blackstone.

The petitioner owns a water privilege and mill in Smithfield, R. I., and also owns land on both sides of the Blackstone River in Smithfield and in Blackstone, which are adjoining municipalities. The Blackstone River runs through Blackstone and Smithfield, and then into Blackstone again. The question before the court was the method of determining the value of the portion of the water power in Blackstone, and the decision approves prorating the total value of the water privilege, exclusive of the power house, on the basis of the amount of fall in the river on each side of the line as developed by the company.

It was contended at the hearings that the special part of the unit privilege which is contributed by the privilege belonging to the land in Blackstone was incapable of valuation; that the valuation of the land and structures in Massachusetts based upon their participation in the value of the whole single water-power development was necessarily a valuation of property in Rhode Island, and that any tax upon this was a violation of the Fourteenth Amendment of the United States Constitution.

The court dismissed this contention and pointed out that, as a matter of law, it is not impossible to make a fair estimate of the relative values in the two states sufficient for assessment purposes.

Coaling Steamers in German Ports

The Hamburg-American line, writes U. S. Consul-General R. P. Skinner, having over a million tons of shipping under its own flag, has perfected special bunkering arrangements at Hamburg whereby whole German carloads of coal are discharged into hatches. Ordinary shipping is bunkered at the rate of 95 pfennigs ($0.226) per ton, and coal can be delivered into hatches at the rate of from 25 to 30 tons per hour per gang. Coal is discharged from the holds at the same speed, but the unloading charge is 65 pfennigs ($0.155) per ton.

At Kiel, bunkering from the quayside is done for 1 mark ($0.238) per ton, or if brought from coal cars, 1.80 marks ($0.428) per ton. If a vessel lies in midstream the charge is also 1.80 marks per ton. Ten tons per hour per gang can be loaded. The coal-discharging fee at Kiel is 35 pfennigs ($0.083) per ton for men working on the vessels who fill the baskets, or 70 pfennigs ($0.166) if coal is unloaded directly into railroad cars or wagons. Coal can be discharged at the rate of 300 to 400 tons per day.

The Lubeck charge for discharging coal is 85 pfennigs ($0.202) per ton; for bunkering, from wagon into bunker, 70 pfennigs; from the barge into bunker, if about level with the ship, 90 pfennigs ($0.214) per ton; or from barge into bunker, if scaffolding must be built, 4 pfennigs ($0.009) or more per ton additional, according to the difficulties encountered. From 20 to 30 tons can be bunkered per hour from coal yards or from lighters, and from 50 to 70 tons can be discharged per hour.

Boston Engineers Club

The Engineers Club of Boston, recently incorporated along the lines of the New York Engineers Club, has decided to take an option on the building at 2 Commonwealth Ave., under lease with the privilege of purchase. On remodeling the building, facilities will be afforded the Boston technical societies in many respects similar to the United Engineering Building in New York. It is expected that the building will be ready for occupancy early in the fall.

Its officers are Ira N. Hollis, president; Charles L. Edgar and Charles T. Main, vice-presidents; Luzerne S. Cowles, secretary; Eliot Wadsworth, treasurer, and a board of governors.

OBITUARY

Charles W. Houghton, for 24 years a faithful and respected employee of the Ashton Valve Co., of Boston, Mass., died on Jan. 18.

George Schuyler Davis, vice-president and secretary of the Kenfield-Davis Publishing Co., Chicago, Ill., and editor of *Electric Traction Weekly*, died, on Jan. 24, at his home in Cleveland, at the age of 37. Mr. Davis was a charter member of the Central Electric Railway Association and an associate member of the American Electric Railway Engineering Association.

SOCIETY NOTES

The tenth annual banquet and reception of the combined N. A. S. E. Associations of Pittsburg, Penn., was held at the Monongahela House on Thursday evening, Jan. 25. After the banquet a pleasing entertainment was given, at the close of which dancing was indulged in by the 500 guests. The combination included Pittsburg No. 3, Allegheny No. 5 and Columbia Association No. 15.

On Tuesday evening, Feb. 13, the American Society of Mechanical Engineers, with the American Institute of Mining Engineers coöperating, will hold a meeting on California gold dredging. Robert E. Cranston, of Marigold, Calif., will present a paper entitled, "Notes on Design and Mechanical Features of the California Gold Dredge." An interesting discussion is also expected from a number of the members of both societies.

The combined associations of the N. A. S. E. of Philadelphia held their third annual concert, dinner and dance at Lulu Temple, on Friday evening, January 26. The audience of about six hundred listened to an entertainment given by the New York "Bunch," and then adjourned to the dining hall, after which dancing was enjoyed. Quaker City No. 1, Tacony No. 9, Merrick No. 12, and Northeast No. 20 were the associations comprising the combination.

PERSONAL

Fred L. Johnson, recently of the editorial staff of POWER, is now with the Brooklyn Edison Co., in the office of the chief operating engineer.

Will M. Glass, of Pasadena, Calif., has accepted the position of day-shift engineer of the Hotel Alexandria, at Los Angeles, said to be the largest hotel power plant in southern California. Previous to this position Mr. Glass was engineer for the Pasadena municipal lighting plant for about five years.

B. A. Brennan, recently contract manager of the Westinghouse Machine Co., and formerly with the E. P. Allis Co., has been appointed sales manager of the power department of the Bethlehem Steel Co., with headquarters at South Bethlehem, Penn., in charge of gas-engine and pumping-engine sales.

C. F. Hockley, for the past three years engineer in the power department of the Bethlehem Steel Co., has been appointed superintendent of the construction power department of that company, with headquarters at South Bethlehem, Penn. Prior to his present association, Mr. Hockley was identified with the Westinghouse Machine Co., East Pittsburg.

BOOKS RECEIVED

ENGINEERING AS A VOCATION. By Ernest McCullough. David Williams Co., New York. Cloth; 201 pages, 5¼x8 in.; illustrated. Price, $1.

THE GASOLINE MOTOR. By P. M. Heldt. *The Horseless Age*, New York. Cloth; 506 pages, 5x8½ in.; 341 illustrations; tables; indexed. Price, $4.

COMMERCIAL DYNAMO DESIGN. By William L. Waters. John Wiley & Sons, New York. Cloth; 135 pages, 5¾x9 in.; 30 illustrations. Price, $2.

MARINE STEAM TURBINES. By Dr. G. Bauer, O. Lasche and M. G. S. Swallow. The Norman W. Henley Publishing Co., New York. Cloth; 214 pages, 5¾x9¼ in.; 103 illustrations; tables; indexed. Price, $3.50.

POWER

Vol. 35 NEW YORK, FEBRUARY 13, 1912 No. 7

Some men take naturally to writing—they are "born writers." With others the task of putting their thoughts in black on white is one to be dreaded.

There is a distinct advantage in being a devotee to the art of letters, no matter whether you become especially proficient as a writer or not. For instance, a man who acquires the habit of writing up notes on his experiences and observations and on what he has read pertaining to his work, etc., is bound to profit in several ways. 'Tis true that "Reading maketh a full man, *writing* a *correct* man, * * * *" And correctness, or accuracy, is a cardinal virtue in engineering. The mere act of writing out his thoughts serves to fix them more securely in his mind.

Often an idea, when hastily or carelessly considered, may seem sound and true; but when the same idea comes to be written out its fallacies or weak points soon show up.

With writing, just as with almost everything else, it is practice that counts. It is said that such geniuses as Dante, Goethe, Macaulay and Darwin were seldom if ever satisfied with the first draft of anything they ever wrote; they continually made revisions and corrections.

This suggests, then, another benefit to be derived from practice at writing, to wit, mental discipline. To be always striving to improve upon what has previously been accomplished is a fine "fault."

Then, there is a direct material gain to be had from this practice. POWER is always glad to receive and consider manuscripts from any of its readers on any subject relating to the generation and transmission of power. If the idea embodied in a manuscript is good, the manuscript is accepted for publication and paid for. In such a case the writer is not only improving in experience, but he is actually getting paid for his practice as well.

For all who are familiar with the construction and operation of a turbine the present time offers a particularly bright opportunity to "pull down" some real money by entering the prize-article contest in POWER which closes on March 1.

The winner will not necessarily be the man who sends in the finest specimen of English composition. He will be the one whose manuscript contains such material that any intelligent engineer who had never seen a turbine before could use as a guide in successfully starting up and operating a turbine such as the particular manuscript deals with.

Even if you are not the winner, you will be paid for your manuscript if it is suitable for publication. Thus, in any event, your work need not be entirely for naught.

Plant of Capital Traction Company

By J. H. Beattie

The rapid increase in electric traction in Washington, D. C., is shown by the fact that the original plant of 2500 kw. capacity, built in 1898, was at the time considered much too large, whereas a new plant of 11,000 kw. capacity has just been completed for handling the increased overload.

For several years previous to 1898 the cars of the Capital Traction Co., of Washington, D. C., were operated by cable power, but in that year the destruction of the power house by fire led to a determination to install electric drive. The power plant installed was located on Grace St., in Georgetown, along the Chesapeake & Ohio Canal, and contained originally five 525-kw., Corliss engine-driven, direct-current units, the station having a total capacity of 2625 kw. This plant was described in POWER at the time, and the company was criticized by many for installing too much power.

By 1907, the demands for power had grown to such an extent that the plant was heavily overloaded, when two of the engines were taken out and two 1500-kw. Westinghouse turbines were installed; these were alternating-current machines. Again, in 1908, the plant was still further enlarged by the removal of another engine-driven unit and the substitution of a 3000-kw. turbo-generator. However, due to the adoption of double-truck cars and to extensions of the system, the power plant soon became inadequate.

The old plant was entirely dependent upon the Chesapeake & Ohio Canal for its supply of water, and a break in the Washington level of the canal at any time would have crippled it very seriously, if not causing a complete shutdown. In addition to this the plant relied upon the canal for its coal supply.

As the building was wholly unsuited to a further increase in the generating capacity, it was decided to build a new plant. This was authorized in January, 1910. Property was purchased at K and Thirty-second Sts., and extended to the river. This location was chosen for several reasons: In the first place, it insured an abundant supply of water for boiler-feed and condensing purposes; and, secondly, coal could be secured either from barges on the river or from the cars on a spur from the Georgetown branch of the Baltimore & Ohio R.R.

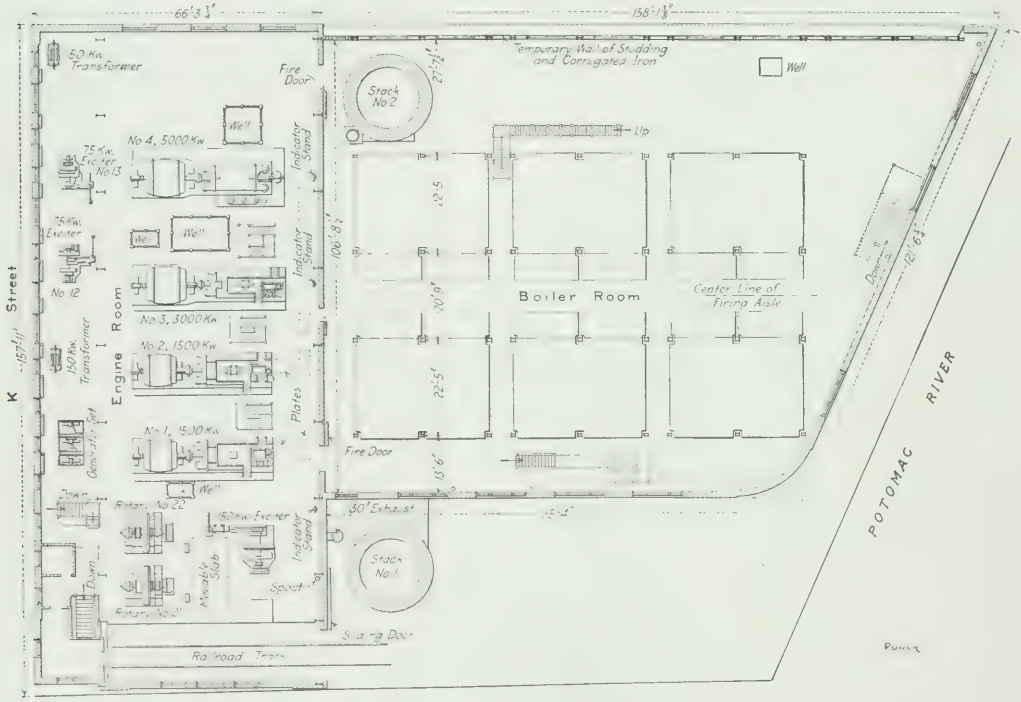


FIG. 1. GENERAL LAYOUT OF PLANT

THE NEW PLANT

The new plant was first put in operation about the middle of last September, and the old plant was practically abandoned a month later, although the removal of the boilers is now just about completed.

In building the foundation, it was necessary to drive a large number of piles to rock on the river side, while on the land side the foundation was dug out of solid rock. Also, on the river side a concrete wall was built which served as a support for the coal spur and the south building wall. A general plan of the plant is given in Fig. 1, which shows not only the part at present erected but also the provision which has been made for future extensions.

FOUNDATION AND SEA WALL

The foundation and sea wall are constructed almost entirely of concrete. The level of the basement floor is 1 ft. above mean high tide, while the turbine floor

is 4 ft. above the highest water ever known on the Potomac River. The basement floor and walls are thoroughly waterproof. The plant could operate under almost any conditions of high water due to a construction of the basement containing the condensers and the arrangement of the circulating pumps.

Boilers

The 12 boilers, which are of the Babcock & Wilcox type, each of 600 hp., are arranged in two rows with a common firing aisle between. Steam at 175 lb. pressure and 100 deg. superheat is carried. Eight of these boilers are new while four are from the Grace St. plant. They are all fitted with Roney stokers and have a grate area of 75 sq.ft. each; they are also fitted with soot blowers.

An interesting plan has been adopted in the boiler room to aid the firemen in taking care of the fires. This is a small track of 18 in. gage laid along the fronts of both rows and carrying a small car bearing a framework about 3 ft. high. This seems to be a great aid to the firemen as they are thus placed in a more advantageous position to handle the fires.

The sheet-steel breechings for the boilers are located in the basement immediately below the boiler room, one on each side extending the length of the room and connecting with its stack. The stacks are of the Alphons Custodis radial brick type, 11 ft. 1 in. internal diameter and 247 ft. high.

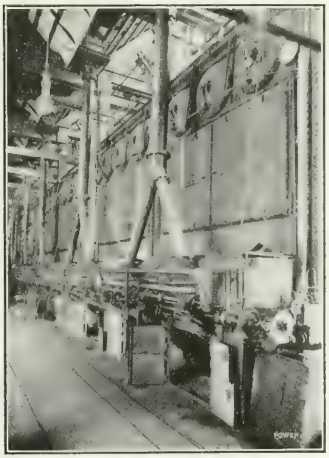


Fig. 2. Looking Down Firing Aisle

Steam Piping

The boiler nozzles are 8 in. and connect to a 12-in. header immediately back of the row of boilers. At the end of the boiler room this header drops to below the floor level, runs through the wall and connects to a 14-in. header running at right angles to this room and parallel to the turbine room. From this pipe the supply pipes of the various turbines are taken. Each boiler nozzle is fitted with a Foster valve so that, in case a tube blew out, the particular boiler to which the accident had occurred would be immediately cut off from the other boilers, thus protecting the plant from shutdown and lessening the danger to the attendants.

In addition to the main steam line, the auxiliary apparatus is supplied with saturated steam from a 6-in. pipe line. All steam piping is heavily lagged with 85 per cent. magnesia covering.

A rather elaborate drip system has been installed by which the drips from the entire high-pressure system are led to two central tanks in the basement provided with automatically operated pumps, whereby the water is returned to the boiler feed as it accumulates.

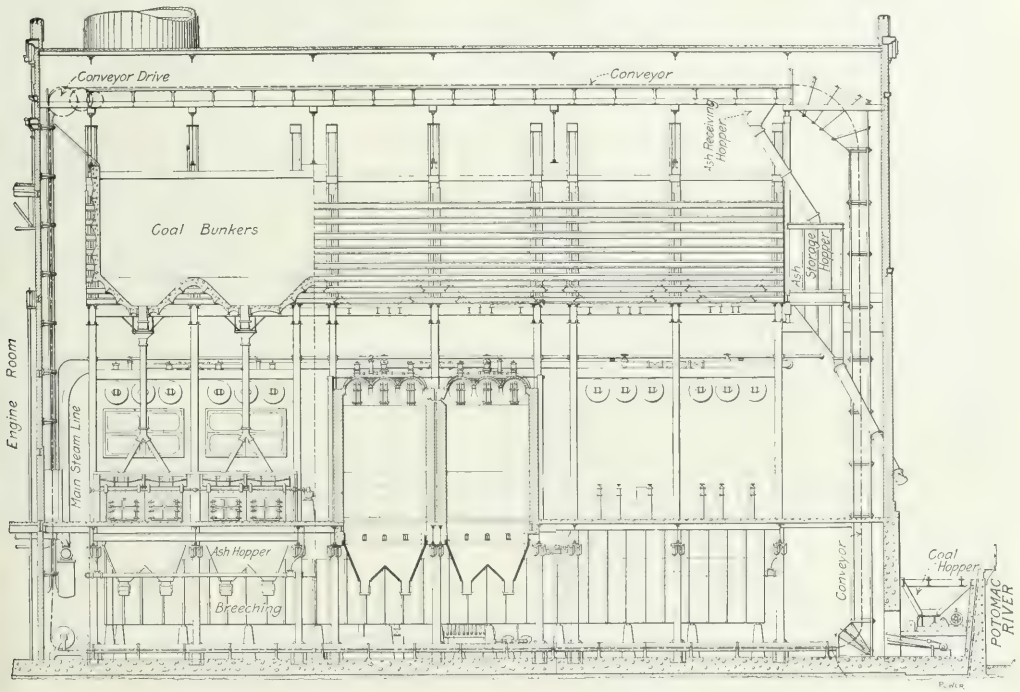


Fig. 3. Longitudinal Section through Boiler Room

Feed-water System

The water supply, both for the condensers and the feed water, is brought into the plant in a reinforced-concrete rectangular tunnel extending through the river wall at the up-stream end of the building and passing through the full length of the engine-room basement. A similar reinforced-concrete tunnel takes

the discharge water from the condensers, running under the full length of the basement and discharging through the river wall at the down-stream end. A well for feed water situated under this basement floor is connected by a 12-in. pipe with both the discharge and intake tunnels. From this well water is taken by two 6-in. vertical submerged centrifugal pumps, each having a capacity of 600 gal. per minute and operated by a 40-hp. induction motor, and is delivered to two large tanks situated on the pump-room roof.

From the tanks, the water flows by gravity either directly or through a battery of Loomis-Manning sand filters, to two Cochrane feed-water heaters, and from these it goes to the boiler-feed pumps.

Coal and Ash Handling

Coal is unloaded from the cars directly into a hopper outside the building on the river wall. Immediately below the hopper is a crusher which reduces all the coal to stoker size. From this it is delivered by a belt conveyor to the main conveyor which is of the endless type, elevating the coal to the bunkers and also carrying the ashes from the ash hoppers under the boilers to a storage bin from which they are discharged by chutes to the cars. The coal bunkers have steel frames, with concrete arches and a total capacity of 1800 tons. They are so constructed that they will completely empty themselves without any trimming of the coal by hand.

Turbine Room

The turbine room is 154 ft. long by 65 ft. high and is finished in green enamel brick for 7 ft. above the floor and has red pressed brick above this. The floor is of "Kompolite," an asbestos preparation of dark red color, furnishing a very pleasing contrast with the finish of the room. The switchboard galleries are of concrete construction and are located on the north side of the room.

At the present time four Westinghouse horizontal turbines are installed. Two of these are 1500-kw. machines, the third has a capacity of 3000 kw., and the fourth 5000 kw. The first three of these machines were moved from the Grace St. station while the largest machine is new. The two smaller machines are served by Wheeler surface condensers and Edwards air pumps; the 3000-kw. machine by an Alberger jet condenser, with the circulating pump driven by a Fleming-Harrisburg engine, and the 5000-kw. machine is equipped with a LeBlanc condenser. The first three turbines are all single-flow machines and the new machine is of the double-flow type.

The writer recently examined the blades of one of the 1500-kw. machines and found very few signs of erosion, and as none of the blades had been renewed during the four years of almost constant use of the machine, this speaks very well for the cost of upkeep for this class of turbine. The machines all operate at 1500 r.p.m. and generate 25-cycle currents at 6600 volts.

There is room in the building as it now stands for another unit of 5000-kw. capacity. Moreover, the company has enough ground on the east of the plant to extend it until the capacity will be at least 30,000 kw.

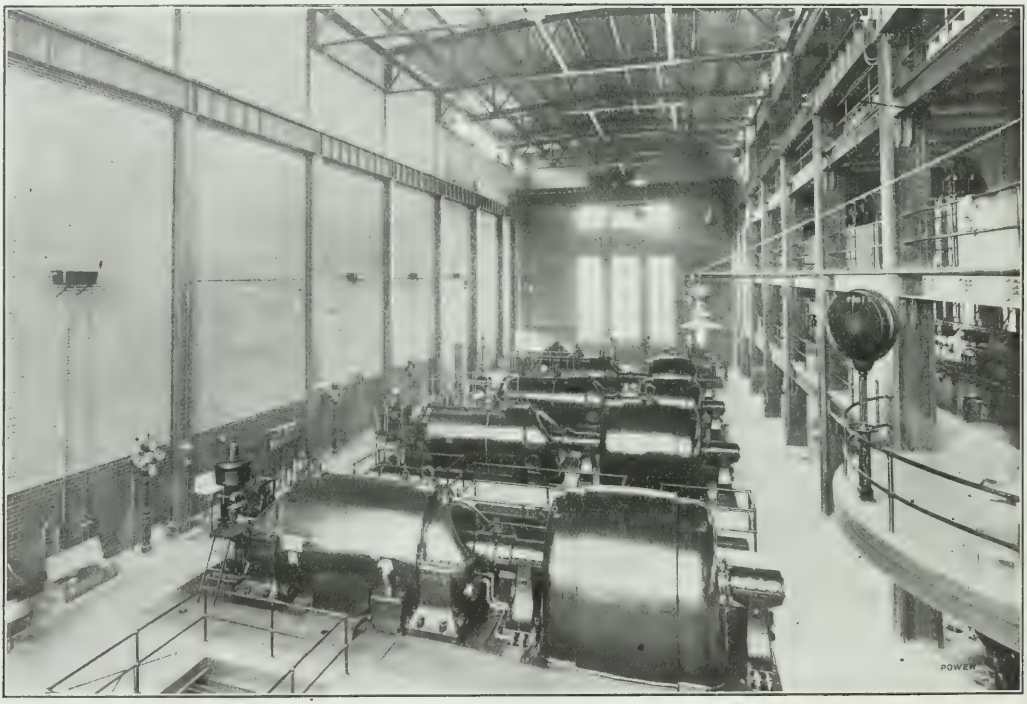


Fig. 4. Turbine Room and Switch Galleries

Auxiliary Apparatus

There are several features of interest in the auxiliary apparatus. In the first place, it was considered more economical to operate these on saturated steam, as the cost of upkeep on the units themselves would be much less than when operating on superheated steam, although the economy is a little less with saturated steam. This is practically balanced, however, because these units exhaust into the feed-water heaters and much of the heat is recovered. The arc lights for

the power house and the lights for the barn and offices of the company are supplied by one 150-kw. and two 75-kw. generators driven by Fleming-Harrisburg tandem-compound engines. There is also a 65-cell, 160-ampere, 8-hr. storage battery floating on the line for emergencies.

Switchboards

The switchboards are arranged in a three-story tier of concrete galleries on the north side of the turbine room, as shown in Fig. 4. The switchboards are laid out with three main divisions, two of which are now installed, the third being for extensions of the plant. Particular attention has been paid to making everything as nearly trouble-proof as possible.

The design and erection of the plant have been under the direction of John H. Hanna, chief engineer of the Capital Traction Co., and the operating engineer in charge of the plant is C. J. Hoshall.

Use of Oil in Steam Lines

By C. F. Holley

The use of oil in headers and steam lines does not appear to be as general as it should be. It is in quite general use on a Michigan mining range where steam lines from 3 to 6 in. in diameter are quite common and one line is 3000 ft. long.

These lines supply steam to the pumps and means must be provided to avoid small leaks. The lines are put in as well as possible and expansion joints are used at intervals, but in spite of all precautions leaks will appear. It would entail considerable trouble and expense to make new joints at such places.

The remedy adopted is to place a lubricator in the boiler house to feed oil into the line. On the start about a quart of oil is daily fed into the line until the leaks have taken up, which does not take over three or four days as a rule, after which the amount is reduced and does not usually exceed one quart per week.

The oil works into the small leaks and cakes there; it also lubricates the expansion joints and prevents erosion of the pipes. Naturally it tends to clog the traps, but it is much easier to clean the traps than to repair the lines in any other way that I know of.

It will surprise one who has not tried it to see how large a leak can be stopped in this way. I have seen a leak in a screwed joint in a line carrying 125 lb. steam pressure, that could be heard at a distance of 200 ft., stopped in this way within 48 hours, and it did not start up again.

I would advise anyone having such trouble on headers or steam lines to try the oil treatment; it can do no harm and it will be found that it will save much annoyance and work.

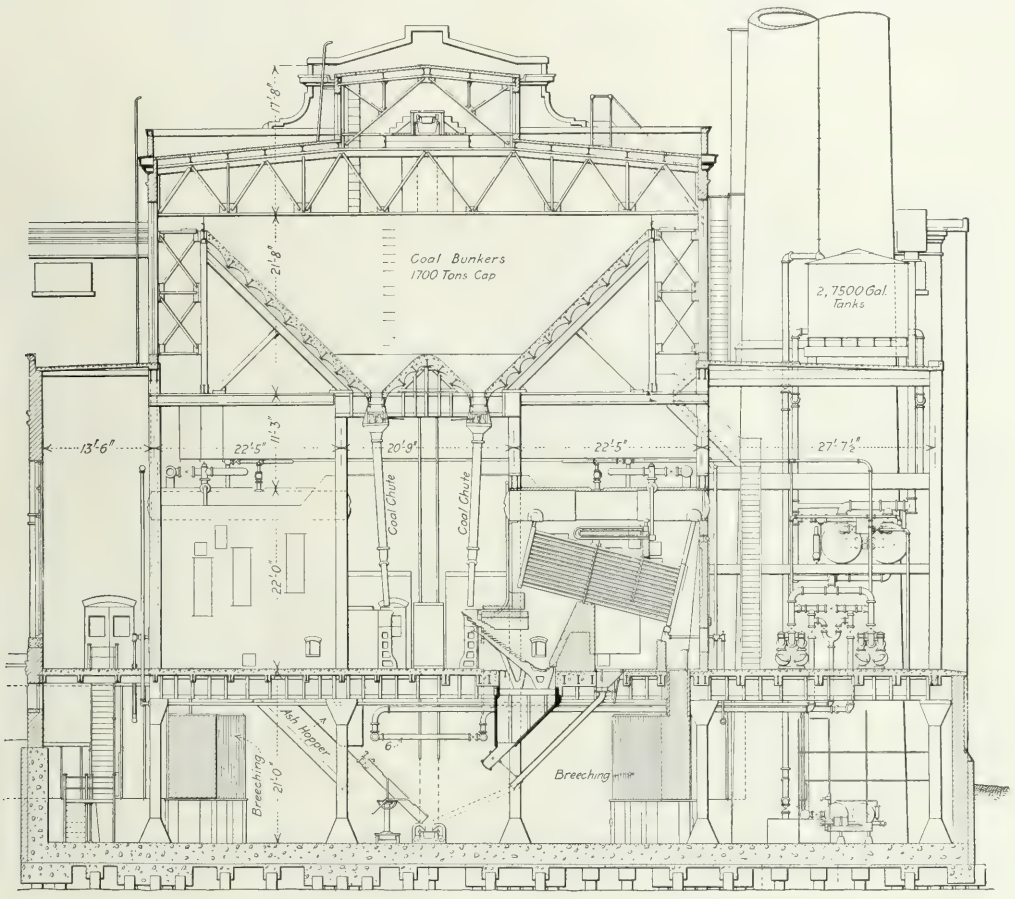


Fig. 5. Cross-section through Boiler Room

James Watt in Cornwall in 1781

By Prof. W. D. Ennis

Facsimile of a letter written by Watt in 1781 to John Hall concerning a contract for an engine and boiler. Brief historical sketch of Watt's work and achievements prior to and during the year 1781.

At about the time of the battle of Bunker Hill, there were hard times in Cornwall; the mines were flooded and the old Newcomen engines could not keep them pumped out.

Fortunately, the young Scotch apprentice, Watt—who had drifted back to Glasgow from London, and, after some difficulties with local labor leaders had been employed in the university—had not only conceived his steam engine, but had formed his life-long partnership with Boulton. The latter was a fine, generous, optimistic, healthy sort of man, industrious, a good manager, a successful engineer and an ideal partner to pull in double harness with Watt. The two built a small plant at Birmingham and began to sell the James Watt steam engines.

For some years Watt lived the intensely active life of an erecting engineer, principally in the mining districts, where the engines were sold on a royalty basis, the builders being paid one-third the value of the fuel saved by the substitution of the new machines for Newcomen engines.

The partners alternated in their residence in the south of England. After considering the building of a portable house, Boulton finally purchased, near Pendennis castle, in the Turnnap valley, not far from Truro, an old-fashioned roomy house and garden called Cosgarne. Here the Watt and Boulton families resided in turn for several years. Fourteen of their engines were within easy reach by horseback; some of them were in sight.

In the year 1781, the Cornwall battle was nearly won, and the mines were saved. Two years later the last of the Newcomen engines was ousted, and Watt considered his next step.

The Polytechnic Institute of Brooklyn has in its possession a letter (presented by J. D. Steele, Esq., Sept. 29, 1869) written by Watt, dated at Cosgarne, Oct. 16, 1781, in which he speaks vividly (if unintentionally) of the condition of things with him at this period. The letter is a discovery, as it does not appear in any of the biographies of either Boulton or Watt.

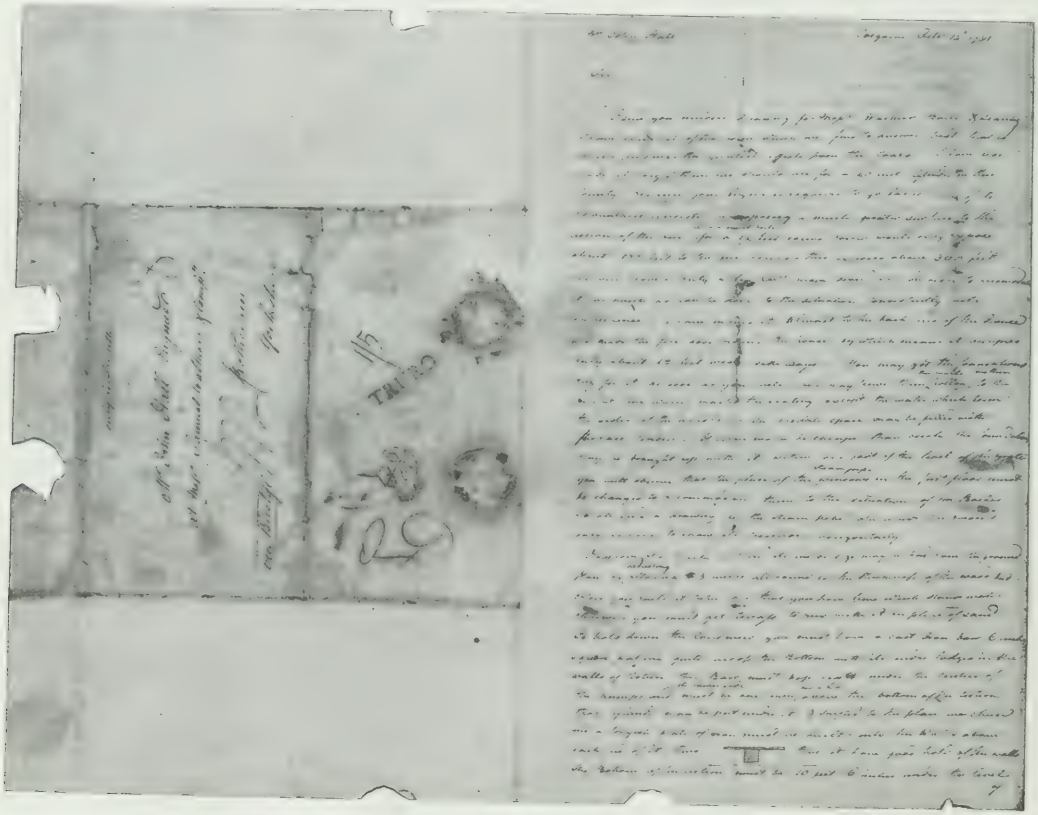


FIG. 1 FRONT SIDE OF THE WATT AUTOGRAPH

The inventor has already built a blowing engine for some firm, the name of which is illegible. The Snow Hill (near Birmingham) and Wilkinson engines, the latter at Bradley, are the only ones of this type of prior date mentioned in the biographies. Watt has now an order from Samuel Walthers & Co., of Roth-

eram ("Walker's ironworks at Rotherham," according to one historian). The builder writes a minute letter of instructions to the local engineer for Messrs. Walthers. He realizes the epoch-making importance of the new application, but understands also that the Walthers firm is interested only in getting their necessary blast.

He is a very busy man. He reached Cosgarne on the first of June. All summer he has been nursing his engines, standing in mine pits, perhaps, throughout the day, keeping up his voluminous correspondence and perfecting his rotatory-movement inventions by night. A confirmed dyspeptic, and in chronic ill health, the climate tires him. He writes: "There is no going out without getting wet to the skin. When it rains in Cornwall, and it rains often, it rains *solid*." He is short of help and appeals to Boulton, "I wish you could find me out a draftsman. I cannot stand it much longer." Again he complains, "my head aches." He speaks of "backache, headache and lowness of spirit"; says he is "stupid and ill and scarcely able to think." He is worried about the Hornblower infringements. Someone has told him of a boiler which evaporizes a hogshead of water from an ounce of coal. His engine building has not begun to pay—it did not, in fact, until 1785—and money matters are distressing him.

Now he has had to rob a little time to make a drawing for Mr. Hall by candlelight. He apoligizes for its inaccuracy, but has guarded against errors in the proper way. He has taken the radical step of greatly increasing the size of boiler, while at the same time adapting it to the location in which it must be installed. He does not seem to mind making the fireman stand outdoors. The most important point in the letter is the statement regarding proposed control of the *vis inertia* of the "belly" piston. It was in this same month—on Oct. 25, just nine days later, in fact—that he took out his patents on the "sun and planet" wheels and on three other devices for transforming reciprocating to rotatory motion. The method now used (with connecting-rod and crank) had already been patented by someone else.

The letter, facsimiles of which are reproduced herewith, gives an intimate picture of the busy, harassed man, 45 years old, winning fame and forgetting his ill health in the hardest kind of work. He has not finished his work; he has not yet made his engine double acting, nor introduced the indicator and the centrifugal governor. Nor has he set himself down (as he did in later years, after he became a Doctor of Laws of Glasgow University) as the opponent of high pressure, compounding, and the railway locomotive. He is the middle-aged man at the best of his powers who has success in sight. A *verbatim* copy of the letter follows:

[Postmark **Truro**]

only double letter

Mr. John Hall, Engineer
at Messrs Samuel Walthers & Comp'y:
Rotheram

via Bristol Yorkshire

Fig. 2. Reverse Side of the Watt Autograph

Cosgarne, Octo 16th 1781

Mr John Hall

Sir—

I send you inclosed Drawing for Messrs Walthers Boiler and seating. I have made it of the form which we find to answer best, that is which produces the greatest effects from the coals—I have also made it larger than we should use for a 40 inch Cylinder in this county, because your Engine is required to

go faster—One of the advantages consists in a much greater surface to the action of the fire, than a round boiler for a 12 feet round boiler would only expose about 170 feet to the fire whereas this exposes above 206 feet and will require only a few cwts more Iron—In order to accomodate it as much as can be done to the situation consistently with convenience, I have moved it almost to the back-end of the House and made the fire door behind the house by which means it occupies only about 12 feet wide sideways—You may get the foundations dug for it as soon as you will, and may leave therin the walls hollow within to the prickit line which marks the seating except the walls which form the sides of the ashole.[1] The middle space may be filled with furnace cinders—If stone work be cheaper than brick the foundation may be brought up with it within one foot of the level of the Grate You will observe that the place of the steam pipe windows in the first floor must be changed to accomodate them to this situation of the Boiler. I shall send a drawing for the steam pipe afterwards the present only serving to show its position horizontally.

I approve of a Brick cistern its inside size may be had from the ground plan by deducting allowing 3 inches all round for the thickness of the wood but before you build it take care that you have lime which stands water otherwise you must get terrass[2] to mix with it in place of sand To hold down the condenser you must have a cast Iron barr 6 inches square passing quite across the Bottom with its ends lodged in the walls of cistern this Barr must pass right under the centers of the pumps and its lower side must be one inch and a half above the bottom of the cistern that Glands may be put under it & shifted to the place we chuse and a longish plate of iron must be built into the Walls above each end of it thus [see sketch near foot of first page of autograph] that it have good hold of the walls The Bottom of the Cistern must be 10 feet 6 inches under the level of the stone platform the Cylinder stands upon—and a sough must be laid to carry away the water when you run off the cistern.

I approve of Blowing with a single Belly[3] and will send you the dimensions suitable to work under a pillar of 6 feet of water which I believe forms a strong enough Blast, if not please advise the strength of Blast used—as to the regulating Belly I have a method of counteracting the vis inertia of its piston at beginning & ending its motion of which will send drawing—I believe 18 inch air pipes are wide enough—The belly cyl'rs should be accurately bored.

I have not been able to make out the list of sizes of materials and as I have no copy of[4] order here can say nothing to it but as soon as I can shall send a list but did not chuse to delay sending this drawing on that account—I shall not send any other drawing of Boiler seating therefore please insert this in the general ground plan when it comes—I have been obliged to draw it by candlelight, by which means it's not so exact as should be but I have marked all the dimensions which are of any consequence—please present my best respects to Messrs Walthers & show them this letter———I am sir

Your Obedient ser't
James Watt

[1]Ashpit.

[2]Terrass, or Dutch trass, a soft rock, burnt and ground.

[3]Obviously a blowing cylinder or tub. An old singular form of the word bellows.

[4]Name of a firm to whom the writer had previously sold a blowing engine.

Samuel Reynolds

The adage, "Once an engineer always an engineer," may aptly be applied to Samuel Reynolds, who for 42 years has been employed by the Lehigh & Wilkes-Barre Coal Co., at the Nottingham Colliery, Plymouth, Penn.

Mr. Reynolds was born in the mining region of Michigan 67 years ago and would feel uncomfortable away from the atmosphere surrounding the mine. For 30 years he has operated the same engine, which is used for slope work in the Nottingham mine, and during his career as a hoisting engineer he has never experienced a serious accident, which speaks well for his ability, quick eye and alertness of mind.

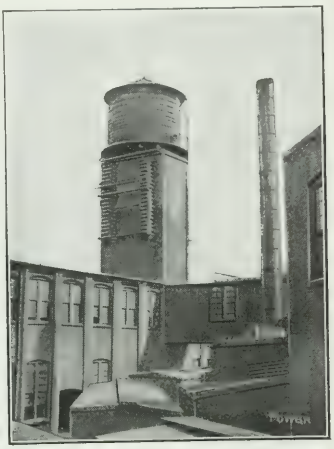
SAMUEL REYNOLDS, FOR FORTY-TWO YEARS A HOISTING ENGINEER

The illustration shows Mr. Reynolds at his familiar throttle and reversing lever. So accustomed has he become to the varying load on the engine that he can form a practically correct estimate of the load he is handling, although the work is hundreds of feet below the surface. He laughs at the thought that a man has passed his days of usefulness when he has reached the age of 50, and he expects to operate his engine for years to come.

Raising a Water Tank

BY A. E. DIXON

Occasionally it becomes necessary to raise a water tank. The accompanying photograph shows how a concern in Cleveland, Ohio, solved a problem of this kind. Holes were cut in the sides of the brick tower supporting the tank so that needle beams could be inserted at a sufficient distance below the tank platform to give room for the four jackscrews used in lifting. These beams also served to support the interior scaffold upon which the bricklayers worked and the cribbing required to support the tank after a lift had been made.



TANK IN PROCESS OF RAISING

The tank rested upon a platform of steel beams. A heavy timber was placed below this and secured to the steel framing, one on each side of the square tower. These served to distribute the thrust of the jackscrews, two on each side of the tower, resting upon cribbing supported by the needle beams. The four jackscrews were operated simultaneously by four men who turned the screws a part of a revolution on a given signal. As soon as a lift was made, cribbing inside of the tower was built up to the tank platform. The jackscrews were then run down and made ready for another lift. When a sufficient height had been gained the bricklayers were set to work and the brickwork was carried up under the tank.

The illustration shows the completed work and the cribbing on one side of the tower supporting the jackscrews. Stringers between the two piles of cribbing served as a working scaffold for the men operating the screws. At the time the picture was taken the jacks were still in place, but they are hidden by the dense shadow under the tank.

Various Types of Steam Meters

By Prof. G. F. Gebhardt

Description of those steam meters in which the steam is throttled and the pressure drop utilized to indicate the flow. In the Feb. 6 issue those meters depending in principle upon the velocity of the steam were considered.

In the group of meters described in the Feb. 6 issue, the indicating and recording mechanism is actuated by the natural velocity of the steam. In the group about to be described the velocity is increased a small amount by throttling and the pressure drop is utilized in actuating the recording mechanism. They may be conveniently classified according to the manner in which the throttling is effected as (1) "floating valve," (2) "stationary disk" and (3) "venturi tube." The weight of steam flowing through the orifice may be calculated from the following modification of equations (1) and (2). (See Feb. 6 issue.)

$$W = AK \sqrt{p_1 - p_2} \qquad (5)$$

in which

W = Pounds discharged per second;
A = Area of the orifice;

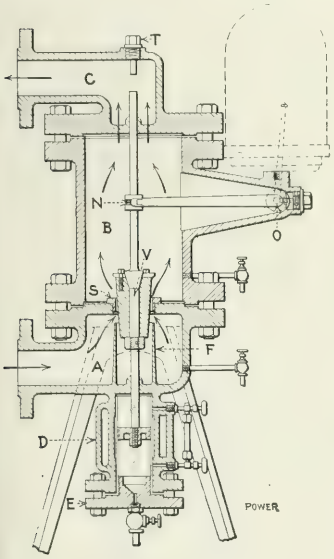


FIG. 1. ST. JOHNS METER

K = Coefficient determined by experiment and includes the density of the steam;

p_1 = Pressure on the inner side of the orifice, in pounds per square inch;

p_2 = Pressure on the discharge side of the orifice, in pounds per square inch.

In some of the meters the pressure drop, $p_1 - p_2$, is maintained constant and the variation in the area A actuates the indicating mechanism, and in others the area is made constant and the variation in pressure drop operates the mechanism.

ST. JOHNS STEAM METER

Fig. 1 represents a section through a St. Johns steam meter, illustrating the throttling type with a floating valve. This meter was placed on the market 20 years ago and still finds favor with many engineers. It records the weight of steam passing through the seat of an automatically lifting valve which rises and falls as the demand for steam increases or diminishes.

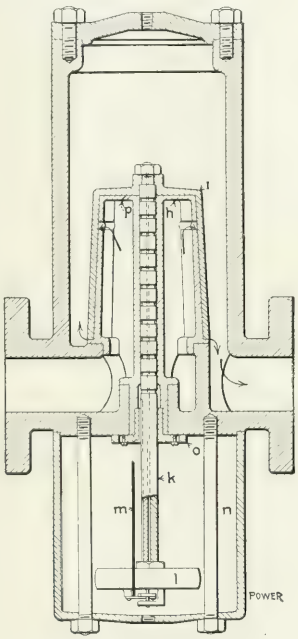


FIG. 2. SARGENT INDICATING METER

Referring to the illustration, valve V is weighted so that a pressure in space A of 2 lb. greater than that in B is necessary to raise the valve off its seat. This pressure difference is constant for all positions of the valve. The plug is tapered so that the rise of the steam pressure is directly proportional to the volume of steam flowing through the seat. The movement of the valve is transmitted through suitable levers to an indicating dial and a recording pen so that the instantaneous and continuous rate of flow may be read at a glance. For a given pressure and quality of steam, the indicating dial and chart may be calibrated to read the weight of discharge directly, corrections being made for variations in pressure and quality. The manufacturers guarantee the readings of the chart to be within 2 per cent. of condenser measurements for a total pressure range of 10 lb. from the mean pressure at which the chart is calibrated.

The chief drawback to this instrument is inherent to all meters of the series type in that they are bulky and the steam line must be taken down for the installation. The total hourly flow may be obtained by integrating the curve. Tests of this meter made by the writer were in accord with the guarantee of the manufacturer for continuous flow and for moderate changes in the rate of flow. For rapid fluctuations in flow the results were not so satisfactory, the greater error lying in the difficulty of integrating the curve correctly.

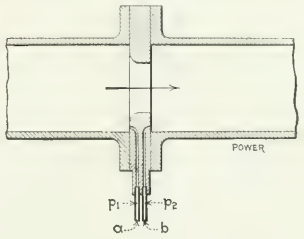


FIG. 3. THROTTLING DISK GEHRE-HALLWACHS METER

SARGENT STEAM METER (1908)

The Sargent steam meter, Fig. 2, differs from the St. Johns meter in that a variation in pressure is automatically compensated for. The principles of operation are the same: steam enters on the left and passes up around the valve stem, and as the pressure increases, flows through the opening p, raising the valve i from its seat and allowing the steam to pass down between the inside and outside cones to the discharge side of the meter as indicated by the arrows. The valve stem k is open to the atmosphere and its exposed area determines the pressure difference necessary to raise the valve from its seat.

Since this pressure difference (about 2 per cent. of the initial pressure) is constant, the lift of the valve will be a direct measure of the amount of steam flowing through the seat. This vertical movement of the valve is transferred by

the indicating needle *m* to a suitably calibrated chart. Pressure correction is automatically effected as follows: A bourdon tube *l* is fastened to the end of the valve stem and rises and falls with the movement of the valve. The valve stem *k* is hollow and connects the bourdon tube with the steam space above

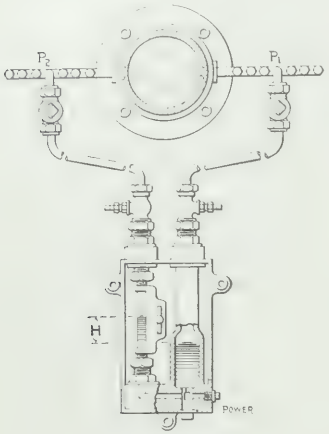


FIG. 4. INDICATING MECHANISM OF GEHRE-HALLWACHS

the valve *i*. Variation in pressure above the valve causes the tube to swing the indicating needle *m* to the right or left, as the pressure increases or decreases. The readings of the chart as indicated by the needle are consequently automatically corrected for pressure variation. Tests of this meter gave approximately the same results as the St. Johns. It is a purely indicating device and hourly results can be obtained only by plot-

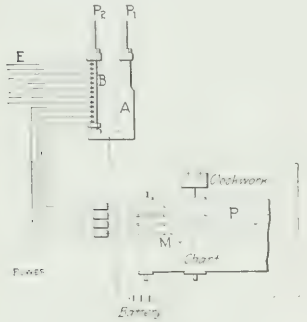


FIG. 5. DIAGRAM OF ELECTRICALLY OPERATED RECORDER

ting the readings at frequent intervals and integrating the curve drawn through them.

GEHRE-HALLWACHS STEAM METERS

The Gehre-Hallwachs steam meters, the results of 20 years of experimenting by Max Gehre, are the most popular in Germany and are being rapidly adopted in England and to a limited extent in America. They are made in a number of styles, indicating, recording and integrating, and cover a wide range of practice. The meter consists of two elements, a throttle disk, Fig. 3, which is permanently inserted in the pipe line at the point where the rate of flow is to be measured and the indicating or recording mechanism (Figs. 4 to 6), which may be placed anywhere below the disk and at any distance from it. One indicating mechanism or one recorder may suffice for a number of disks, provided, of course, continuous records are not desired from each.

Referring to Fig. 3, variation in the rate of discharge through the orifice which is of constant diameter will cause the pressure difference, $p_1 - p_2$, to vary, the maximum pressure difference being less than 1 lb. per square inch. Pressures p_1 and p_2 are transmitted to the indicator or recorder through the small tubes *a* and *b*. The general details of the indicating mechanism are shown in Fig. 4; which is a simple mercury manometer. For general purposes, the apparatus is fitted with a revolving chart calibrated for different pressures and qualities of steam. Great care must be taken in adjusting the chart for the required pressure, pipe diameter and quality of steam, all leaks must be eliminated from the piping and the entire system must be freed from air pockets. These precautions apply equally well to all meters involving the use of mercury manometers.

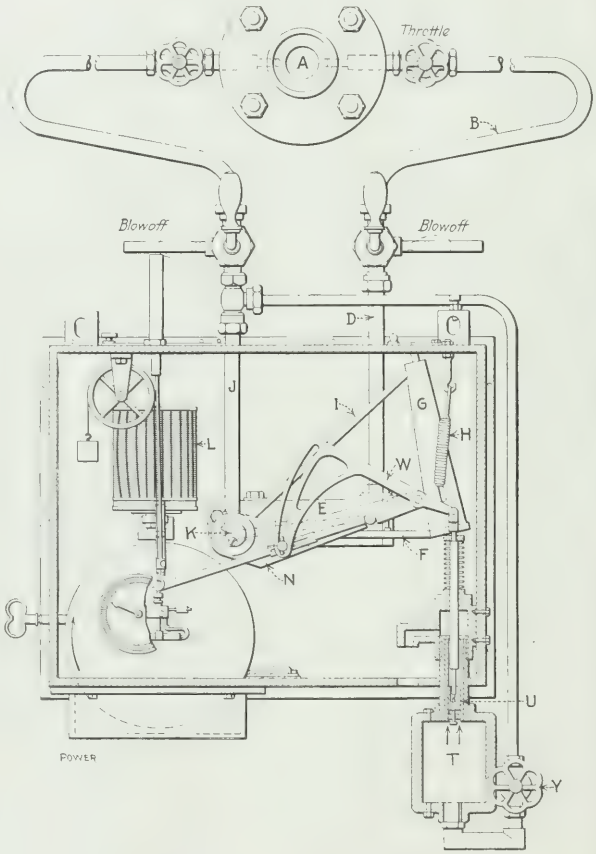


FIG. 6. SARCO AUTOGRAPHIC INDICATING AND INTEGRATING METER

Two styles of recorders are manufactured for this meter, one electrically and the other mechanically operated. The principles of the earlier form of electrically actuated recorder are shown in Fig. 5. A number of electrical terminals *E* are inserted in column *B* of the mercury manometer. As the mercury rises it closes a corresponding number of circuits which in turn actuate magnets *M*. These magnets perforate at regular intervals a clock-driven chart *P*. The contour formed by the perforation records the

height of the mercury column and hence is a measure of the weight of steam flowing through the throttle disk. The accuracy of the perforated record is necessarily dependent upon the spacing of the electrical terminals. No automatic compensation is made for pressure variation or change in quality.

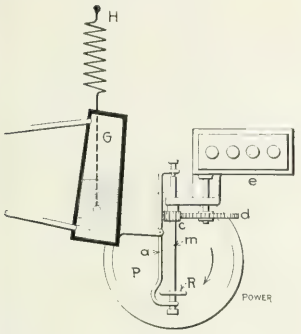


FIG. 7. SHOWING PRINCIPLES OF SARCO METER

In the later type of electrically operated recorder, the different circuits actuate a solenoid, the core of which is fastened to the recording pin. Automatic compensation for pressure variation is effected by a bourdon tube which varies a resistance. By connecting the different circuits to a small motor the speed of the latter may be varied according to the height of the mercury column in the manometer. This forms the basis of the integrating meter.

The meter fitted with indicating, autographic and integrating devices represents the nearest approach to ideal station practice, since the instantaneous rate of flow, the rate of flow for any length of time and the total flow for a given period are always available, and the electrical control enables it to be placed at any distance from the steam pipe, thus

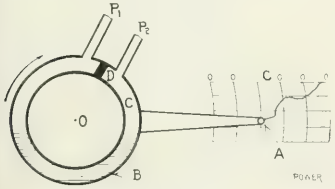


FIG. 8. SHOWING PRINCIPLES OF THE STORRER METER

facilitating centralization of all meters. The success of these instruments is evidenced by the fact that 7000 of them have been installed in Germany during the last two years and the German government has adopted them for official tests in its department of boiler inspection.

The mechanically operated recorder and integrator is shown in Fig. 6, and the principles of operation are illustrated diagrammatically in Fig. 7. This instrument is manufactured in England under the name of the Sarco steam meter. Referring to Figs. 6 and 7, the high-pressure side of the throttle disk is connected through pipe D to reservoir E which is filled with mercury; this is connected by a tube F to a hollow cone-shaped vessel G. The cone G and its connecting tubes F and I are suspended from springs H, one on each side of the cone, and are free to move about the trunnion K. It is evident that the pressure difference, $p_1 - p_2$, acting through the water in D will force the mercury in E out along tube F into the cone G, causing the latter to sink. The recording pen is fastened to the cone and hence traces the movement of the latter on the clock-driven chart L.

This mechanism differs from the General Electric recording meter in that the motion of the pen is directly proportional to the weight of steam flowing and hence the chart may be integrated with an ordinary planimeter. This is brought about in a very ingenious way. The height of the mercury in G varies approximately as the square of the weight of steam flowing through the throttle disk, so that the weight of mercury in G (and consequently the movement of the pen) would vary correspondingly if the vessel were cylindrical. By tapering G so that the weight of mercury increases approximately as the square root of the height, the pen movement is made to vary directly with the flow of steam.

This uniform motion of the pen makes it not only possible but comparatively easy to add an integrating mechanism. Referring to the detail, Fig. 7, R is a small friction wheel mounted on the pen arm a and connected to gears c and d by the small shaft m; P is a clock-driven disk in contact with the friction wheel R.

As the pen arm moves the wheel R in and out from the center of disk P, the speed of the small friction wheel is decreased or increased accordingly. The

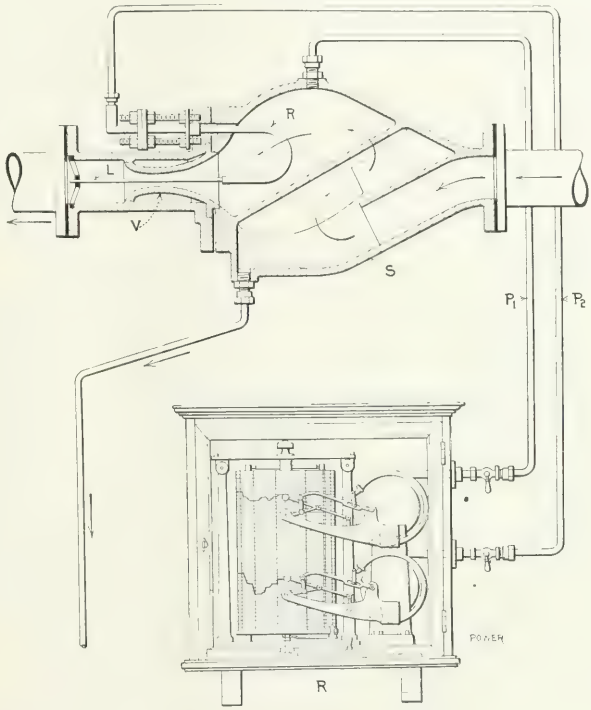


FIG. 9. ECKARDT STEAM METER

revolutions of R are transmitted to the integrating mechanism e so that the total flow may be read directly from the dials. Variation in pressure is compensated for by the spring-resisted piston U, Fig. 6, which increases or decreases the displacement of the pen.

STORRER STEAM METER

A novel manometer for recording small pressure changes is used by Storrer in his autographic indicating steam meter. The principles of operation are shown diagrammatically in Fig. 8, in which B is a hollow torus-shaped vessel, partially filled with mercury and free to rotate

about the axis O. Diaphragm D divides the upper portion into two parts. The opening P_1 is connected to the high-pressure side of a throttling disk and the opening P_2 to the low-pressure side of the meter.

The pressure difference tends to force the mercury up into chamber C; this increases the leverage on the right and causes the vessel and the attached recording arm to rotate clockwise until equilibrium is established. The deflection of point A is a measure of the pressure difference and consequently of the weight of steam discharged. Correction for pressure variation is automatically effected by a small steam piston which changes the position of the pen-arm pivot relative to the axis of the torus. The apparatus is compact, portable and easily applied, but it is not as sensitive as other meters of the mercury manometer type on account of the great inertia of the torus and the friction of the trunnions.

Eckardt's Steam Meter

The venturi tube has been used as a steam meter in Europe for a number of years and is finding some favor in this country. A section through the Eckardt recording steam meter is shown in Fig. 9. It consists essentially of a steam separator S, a venturi meter V and a pressure recorder R. The pressure at the throat is transmitted by pipes L and P_2 to a clock-driven recorder and the pressure at the entrance is transmitted by pipe P_1 to a similar recorder. The difference in pressure is a measure of the weight discharged and may be easily calculated. Tests of the meter proper have given consistent results, but the use of two pressure charts is awkward and unsatisfactory. No automatic correction is made for pressure variation.

The Builder's Iron Foundry have adapted their venturi meter to the measurement of steam with some success. The writer found the meter proper to agree within 3 per cent. of the condenser readings for continuous flow and for constant initial pressure and quality, but he did not have the opportunity to test out the recording apparatus.

Perenty Steam Meter

The latest form of Perenty steam meter is perhaps the most convenient application of the venturi tube to the measurement of steam. The pressure difference actuates a tilting column similar in principle to that of the General Electric recorder and the automatic pressure correction is made in a similar manner to that illustrated in Fig. 6.

The chief objection to the venturi type is that the piping must be disconnected when installing the meter.

In conclusion, it may be said that the average high-grade steam meter is a reliable and accurate means of measuring the flow of steam in straight lengths of pipes provided the flow is continuous, or that the change in the rate of flow is gradual and the pressure and quality are practically constant. For interrupted or intermittent flow and for sudden variation in pressure or quality, the results are not reliable and may be considerably in error. The accuracy of all meters, provided they have been correctly calibrated and adjusted, depends largely upon the degree of refinement in reading the indicators and in integrating the charts. The commercial failure of many steam meters is due to the fact that they are not cared for or operated in strict accordance with the principles of design.

Progress in British Marine Engineering

Marine engineering in Great Britain has been making steady progress, says the Glasgow *Herald* in its review of the year's work. The reciprocating engine continues to hold its own, and is bigger, more economical, and its cost is less.

The most striking tendency of progress has been to take the auxiliaries off the main engines and drive them independently.

Making of Turbines

More marine turbines of the Parsons type were made in 1911 than in any preceding year, the Parsons Co. reporting that, up to June 30, about 6,400,000 hp. had been made, of which 1,900,000 hp. belonged to 1910-11. At the commencement of the last half of this period machinery of 2,740,000 hp. for 167 British and Colonial warships was under construction.

The effect of this naval forcing has indirectly helped mercantile shipping, and has aided in the development of the turbine to commercial requirements. The reaction type, working in series on three or four shafts, has proved so successful for high-speed merchant ships that only in detail does it seem to be susceptible to improvement.

Merchant Marine

A combination in which reciprocating engines exhaust into low-pressure turbines finds particular favor for ships of intermediate speeds similar to the "Titanic" type.

The success of the transmission system, which was installed experimentally on the steamer "Vespasian," has been unmistakable and its tardy adoption is only explained on the score of high first cost.

Turbines geared in this way are economical for slow speeds and the transmissions are efficient and reliable. After 32,000 miles of work in the North Sea, in all kinds of weather, the "Vespasian's" pinions and gear wheel showed no appreciable signs of wear, neither gear nor turbine giving the slightest trouble. No other transmission system has been tried on the Continental side of the Atlantic on the scale of an ocean-going vessel.

But little information is available of the Brown-Curtis turbines because this type is exclusively used in protected cruisers and destroyers in Great Britain, but it is finding favor in the Italian navy.

Improved Auxiliaries

The value of improved engine-room auxiliaries in the development of the turbine is probably higher than in the reciprocating engine, because with a vacuum guaranteed by the maker of the condenser the design of the turbine is simplified. Weir's uniflux condenser and dual air pump, says the *Herald*, have not only achieved wonders in this direction, but they have enabled the turbine makers to do so. They have been adopted by Great Britain, Argentina, China, Chile, Italy, Russia, the United States, Austria, France, Brazil, Denmark, Japan, Spain and Turkey, and for high-vacuum turbine-driven merchant vessels they are practically the standard. Already they have been applied to machinery representing 4,000,000 shaft horsepower.

Minor Developments

There are worthy of note two minor developments, one relating to the use of superheated steam and the other to oil fuel. The chief objection to superheating has been an unsatisfactory superheater, but a steamer designed for reciprocating engines is to be equipped with the Schmidt superheater, which, it is understood, has given excellent results on vessels based on Continental ports.

The oil development is the association of Howden forced draft with the system of oil burning specialized so successfully by a well known British engineering firm. In 1911, installations have been made representing nearly 150,000 hp.

Oil Engines

The oil engine is still in an experimental stage, so far as ocean-going shipping is concerned, although 13 oil-engined vessels, from 4500 to 8000 gross tonnage, are being built according to Lloyd's classification, and six vessels, from 100 to 3800, to the British Corporation classification.

Vessels built to Lloyd's class have both two-stroke and four-stroke engines, one of the two-stroke being of the double-acting type. For marine work the two-stroke, single-acting type seems most suitable.

Russia's peat industry has 78 firms engaged in the production of this fuel; they put out the equivalent of 544,500 tons of hard coal in 1908.

It is stated by *Coal Age* that Russia's peat deposits are sufficient for all demands for at least 40 or 50 years.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Gas Turbine*

By Prof. J. Lange

The development of the efficient turbo-compressor first brought the gas turbine within the reach of possibility. The use of piston compressors in connection with gas turbines is inevitably futile, as the required work transfer from the turbine to the compressor shaft is impossible for the high duties in queston and with reference to economy and practical operation.

No-compression Type

Hence it was next sought to avoid the compressor entirely and the explosion turbine was produced; its thermic cycle being that of the first piston gas engine of Lenoir, with the exception that in the gas turbine expansion is continued to atmospheric pressure. The fuel-air mixture at about the pressure of the atmosphere is exploded in the explosion chamber (Fig. 1) by electrical ignition; this chamber being closed against the inlet passages by a positive check valve. The gases of explosion flow through a longer passage to the nozzle in which the static energy is converted into kinetic energy. Through the sluggish action of the gases leaving the nozzle and through the cooling of the residual gases, there occurs a partial vacuum in the explosion chamber which opens the check valve and permits the inflow of a fresh charge. Like thermal conditions obtain during the suction stroke of the piston type inasmuch as the cooling of the waste gases results, even though slightly, in an increased volumetric efficiency. De Karavodine, of Paris, has brought out such a design of turbine.

The pressure variation in the explosion chamber is shown in Fig. 2. The drop to below the atmosphere is worthy of notice; on that the compressorless explosion turbine depends. The fuel consumption was about 6.6 lb. of benzine per effective horsepower per hour; substantially higher than in the first Lenoir reciprocating gas engine. Besides the lower efficiency of the noncompressor thermal cycle, the unsatisfactory fuel utilization by this machine may be attributed to the marked contamination of the fresh charge by the residual gas, and to the unfavorable hydraulic method of impingement of the gases.† To overcome this latter disadvantage the connection of a plurality of explosion chambers was made to one nozzle with a view to a more constant gas flow (see Fig. 3). The results obtained, however, are not known.

Beyond doubt, the fuel utilization of the explosion turbine is capable of improvement, as there cling to it now all the disadvantages resulting from the intermittent method of operation. It is just that intermittent action which it is the purpose of the turbine to avoid, and it is the resultant general advantages springing from such avoidance that have helped the steam turbine to victory over the reciprocating engine, not that the turbine itself could offer any particular advantages in the utilization of the steam. In the gas engine, the avoidance of intermittent action is of extreme importance because the disadvantages of rapidly succeeding temperature and pressure changes attain a much higher measure than in a steam engine. If then nothing more be done than to replace the piston and driving parts of the reciprocating engine by the nozzle and wheel of the turbine, there will be no advantage unless there result therefrom a gain in fuel utilization. That, however, is entirely out of the question as the losses in the nozzle and in the wheel buckets are materially greater than in the driving parts of the reciprocating engine. Under such circumstances the capacity for development of the explosion turbine must be considered as excluded, for it has all of the inherent defects of the reciprocating engine without showing any advantage thereover.

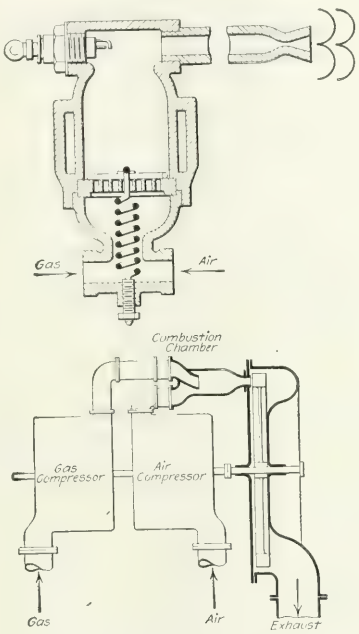


Fig. 1. Intermittent Type
Fig. 5. Contact Pressure Type

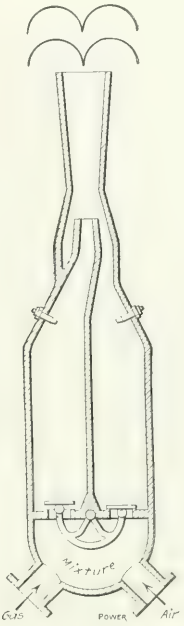


Fig. 3. Multiple Combustion Chambers

Constant Pressure Type

The operation of the constant-pressure turbine is not intermittent, and therefore it has a marked superiority over the explosion turbine. Gas and air are compressed and, after having been heated by the exhaust gases of the previous combustion, are conducted to expansion nozzles. The heating results in an increase of volume so that the positive work of the turbine is greater than the negative work applied to compression (see Fig. 4). Fundamentally, the source of heat

*Translated for Power from an article originally published in *Stahl und Eisen*.

†The term "hydraulic" here is taken by the translator to mean jet and bucket losses in the way these would be considered in the operation of a waterwheel such as the Pelton.

increment is unimportant be it directly from the preceding combustion of the working medium or from extraneous heating of the latter. In the latter case the gas turbine becomes purely a hot air turbine. The heat transfer through combustion of the working medium is fuller and more economical, but of course this requires clean fuel, combustion without residue and such chemical condition of the gases of combustion that the material of construction of the machine will not be attacked.

The principal parts, therefore, of a constant-pressure turbine unit are the compressor, the combustion chamber and the turbine proper (see Fig. 5). For reasons of safety, the compression of gas and air must be separate. Instead of a compressor an exhauster may be used,

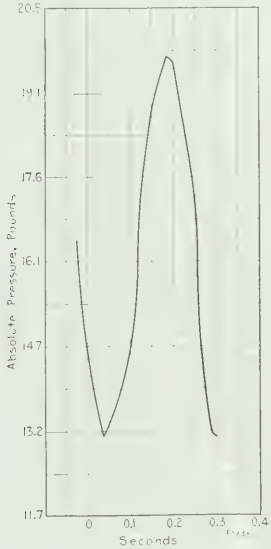


FIG. 2. PRESSURE VARIATION IN COMBUSTION CHAMBER

drawing the waste gases from the turbine housing through a cooler and expelling them at atmospheric pressure (see Fig. 6). In this case the gas and the air flow at atmospheric pressure to the combustion chamber. The gases of combustion expand in the nozzle to a pressure due to the partial vacuum created by the exhauster. It is thermally insignificant whether the cycle operates above or below atmospheric pressure when the laws governing the expansion and compression are the same and if in both cases there exist the same ratios of expansion and compression.

As between the compressor and the exhauster, practical operation must decide which is the better of the two methods of operation, or whether a combination of the two, as in Fig. 7, would be the more advisable; the turbo-compressor and the turbo-exhauster are, themselves, the deciding factors. For light loads the working limit would, more fittingly, be below the atmosphere on account of the small quantities of gas and of air and to attain greater specific volumes and at the same time sufficiently large passages. For heavy loads a higher pressure zone would be chosen in order to be able to control the gas masses.

In its capacity for control of large volumes with constructive simplicity and cheapness and for utilizing the lower areas of the diagram without materially increasing the friction load, the turbine has an adaptability not possessed by the reciprocating engine. This characteristic will have to be taken advantage of as far as possible and a substantially greater expansion ratio chosen (about 50) than is usual in the reciprocating engine. Thus it is self-evident that there must be a division of the cycle into plus and minus paths with reference to the atmospheric line, as otherwise the maximum and minimum absolute pressures could not be maintained within reasonable limits.

Along with the exhauster, as one of

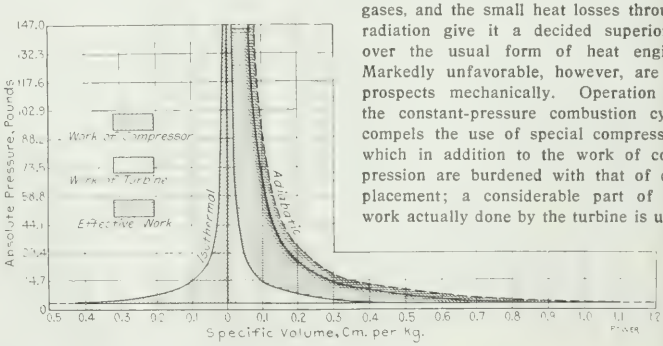


FIG. 4. CHART OF WORK DISTRIBUTION

the main accessories of the constant-pressure turbine outfit, comes the cooler, but it would not be advisable to allow the heat abstracted from the waste gases to be lost; it is preferable to recover it. This is accomplished by making use of the compressed fresh charge as a cooling fluid to the end that the charge reaches the combustion chamber preheated, and the specific volume and work capacity of the heated gases are increased (see Fig. 4).

The possibility of recovering, at least in part, the heat of the waste gases in a relatively simple manner indicates a further advantage of the gas turbine as compared with the usual heat engine, where a recovery of waste heat for utilization within the engine cycle proper is not available in practice.

An entirely new problem confronting the designer of a gas turbine is the formation of the combustion chamber. Even if, as a preliminary requirement, a recognized good type of gas burner can be used for that chief essential, perfect combustion in short space, there still remains to be overcome the difficulty in the matter of high temperature in connection with the stresses in the walls of the combustion chamber. One way of accomplishing this is shown in Fig. 8, where the compressed gas or compressed air is allowed to circulate around the actual combustion chamber, whereby its walls are relieved from pressure and hence in the matter of material therefor there remains to be considered only its fire-resistance without reference to its strength. In addition this design of combustion chamber offers the further thermal advantage that heat loss through external radiation is practically eliminated.

MECHANICAL DRAWBACKS

At all events, the thermodynamic prospect of the gas turbine is unusually favorable. The high expansion ratio, the simple and practical possibility of partial heat recovery from the waste gases, and the small heat losses through radiation give it a decided superiority over the usual form of heat engine. Markedly unfavorable, however, are its prospects mechanically. Operation on the constant-pressure combustion cycle compels the use of special compressors which in addition to the work of compression are burdened with that of displacement; a considerable part of the work actually done by the turbine is used up, therefore, for compression. It is evident that the losses in the unit parts of the aggregate turbine equipment, with reference to the proportionately small effective service, are very large and can become so great that in general there can be no further net work delivered.

The rapid and unexpected advances of turbine compressors, however, place the gas turbine in a somewhat more favorable light. Isothermal efficiencies of 67 per cent. have already been reached and will probably be raised to 70 per cent. Fig. 9 shows the total efficiencies, with and without heat recovery, of a complete turbine outfit based on different turbine efficiencies and assuming a compressor efficiency of 70 per cent. The solid lines apply to the condition that heat is not recovered from the waste gases; the

dotted lines are based on full recovery thereof by preheating the new charge; and according to the completeness of recovery of such heat will the actual efficiency lie between these lines. If the turbine efficiency be 50 per cent. the complete unit can, with its then overall efficiency of from 11 to 20 per cent., compete with a good steam-power installation in the matter of fuel consumption. Should the turbine efficiency be brought to 65 per cent., the overall efficiency would lie between 24 and 35 per cent. and the gas-turbine unit would then show the fuel consumption of the best gas engine.

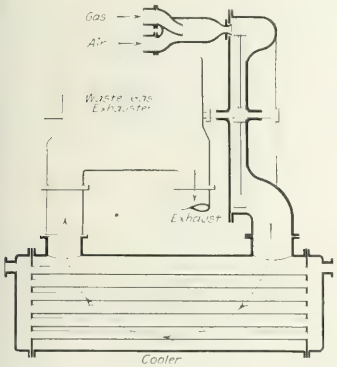


FIG. 6. EXHAUSTER USED INSTEAD OF COMPRESSOR

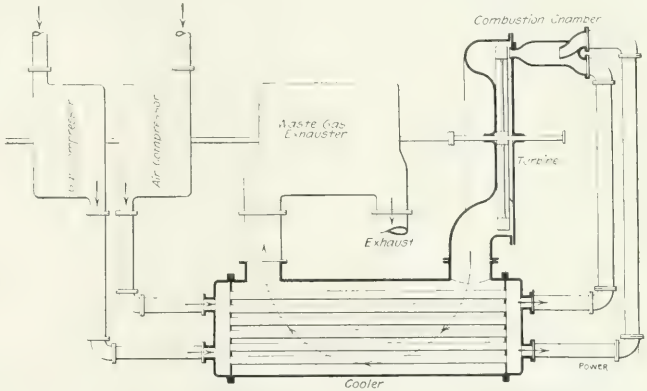


FIG. 7. COMBINATION OF COMPRESSORS AND EXHAUSTER

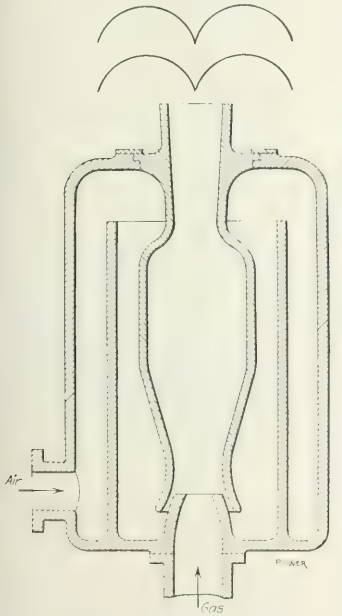


FIG. 8. PRESSURE-JACKETED COMBUSTION CHAMBER

In steam turbines, by means of suitable staging, an efficiency of 50 per cent. has been successfully raised to nearly 70 per cent. In the gas turbine, the high temperatures of the operating medium present an insurmountable obstacle in the way of a like development. If, in order to obtain a good turbine efficiency, the high-pressure gases heated to the temperature of combustion are allowed to expand in stages, the cooling of adiabatic expansion in the individual stages is so small that the temperatures of the initial wheels of the rotor become unmanageably high. In addition, through the necessity of keeping the bearings cool, such great temperature differences occur in the individual wheels that distortion thereof and consequent vibration of the rotor are unavoidable. These difficulties can be prevented by single-stage expansion, as through the assumed adiabatic expansion ratio of 50 the terminal temperatures are kept within acceptable limits. Nevertheless, the mechanical and bucket losses operate toward a poorer fuel utilization by such a gas turbine equipment than that shown by steam-power plants.

It has been variously sought to avoid temperature troubles by cooling. Still, all cooling methods result in heat losses, be the temperature reduced in the simplest way through surface action or through the introduction into the fuel of neutral media; although to that end the water spray must, from a practical viewpoint, be regarded as an attractive means, inasmuch as the hydraulic and mechanical advantages of staging, possible only through temperature lessening, very likely outweigh the heat losses. The disclosure of a favorable compromise between turbine and thermal efficiencies must be reserved for experiment. However, in the light of knowledge now available, it can be stated with certainty that an improvement in fuel utilization over that of the reciprocating gas engine cannot be expected from the gas turbine.

There still remains to be investigated the question as to whether the gas turbine can offer advantages in the way of installation and service costs. The necessity of installing a large plant places the turbine in an unfavorable position in competition with the usual heat engine. Even under the most favorable condition imaginable the output factor of the gas-turbine equipment (the effective load divided by the total capacity of the plant installed) amounts to only about 33 per cent. (see Fig. 9); for example, in order to carry an effective load of 1000 hp. there would have to be provided a 2000-hp. turbine and a 1000-hp. compressor. Hence it results naturally that an immediate saving in installation and operating costs is not to be expected. Only the need of power units the size of which would lie outside of the sphere of the reciprocating engine can bring the gas turbine within the field of usefulness.

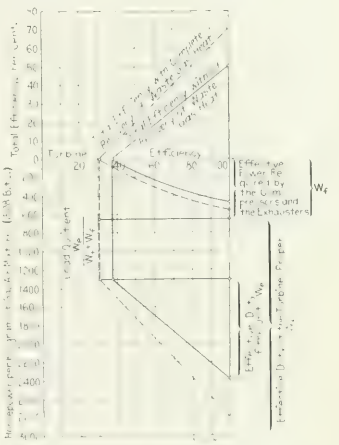


FIG. 9. POSSIBLE RESULTS

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

Arc Lamps

1189. *How is light produced in an arc lamp?*

By passing current through two carbon rods held in line with each other with the adjacent ends a short distance apart. The current bridging the gap between the carbons produces a brilliant arc which gives to the lamp its name.

1190. *Does the arc produce all the light given off?*

No; the greater portion of light comes from the ends of the carbon rods which become white-hot under the influence of the current.

1191. *Is direct current or alternating current used?*

Some arc lamps work with direct current and others with alternating current.

1192. *Does not the current burn off the ends of the carbons?*

Yes; the ends are slowly burned away; the length of the positive carbon is reduced much more rapidly than that of the negative carbon, in a direct-current lamp with an unshielded arc.

1193. *Why does the positive carbon burn more rapidly than the negative?*

It does not actually burn more rapidly; its length is reduced more rapidly because some of the particles of carbon detached from the positive rod are carried across the arc by the current flowing from the one rod to the other and are deposited on the tip of the negative rod, replacing an equal quantity of carbon particles burned off by the arc.

1194. *Does this have any other effect besides the difference in the rates of shortening the two rods?*

Yes; the flow of current from the positive to the negative carbon hollows out the end of the positive rod and the deposit on the end of the negative carbon builds up that end into a sort of peak, as indicated in Fig. 398. The arc eats away the edge of the negative carbon tip and gradually undermines the peak, which breaks off. A new peak is then formed gradually and later broken off, and so on, until the rod is consumed.

1195. *Which carbon furnishes the greater portion of the light given off?*

The positive carbon, which has the hollowed end, or crater, as it is called.

1196. *Is the positive carbon placed above the negative one, as represented here?*

Yes, usually; in order that the intense light from its crater may be cast downward, where it is most needed.

1197. *What is the color of the light from an arc lamp?*

The color of the light depends upon the composition of the carbon rods. If there are impurities in the carbon, the color will vary considerably. Ordinarily, the light is tinged with violet but is very brilliant, closely resembling sunlight.

1198. *How much light does an ordinary arc lamp give?*

There are two common sizes of open arc lamps rated respectively at 1200 and 2000 candlepower.

1199. *How much current is required by the ordinary direct-current arc lamps?*

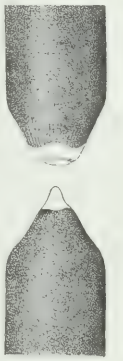


Fig. 398

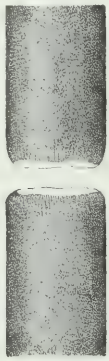


Fig. 401

Direct-current arc lamps in which the arc is not protected from the surrounding air require 6.8 amperes in the 1200-cp. size and the 2000-cp. lamp takes 9.6 amperes.

1200. *What voltage is required by an ordinary arc lamp to force the current across the arc?*

About 46 volts. This includes about 3 volts to overcome the resistance of the carbons and about 3 more to overcome the resistance of the lamp magnet and connections, leaving about 40 volts applied to the arc itself.

1201. *How long will the carbons in an arc lamp burn before they have to be renewed?*

The rate of consumption depends largely upon whether the arc is "open" (not shielded), as in Fig. 399, or inclosed, as in Fig. 400. In the former case the arc is freely surrounded by air and burns the carbons rapidly; in the latter it is inclosed in a small inner glass globe that practically excludes the air, and the consumption is therefore much slower owing to the restriction of oxygen in the inner globe. The rate of consumption for an open arc ranges from 1 to 2 in. of positive carbon per hour;

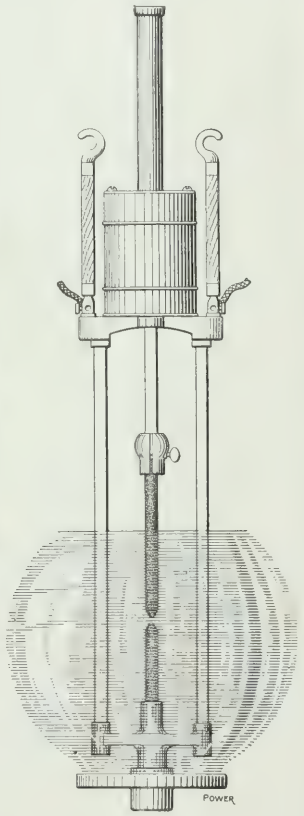


Fig. 399. Open-arc Lamp

the rate for an inclosed arc ranges from 0.07 to 0.10 in. per hour. The rate depends on the size and composition of the carbon rods and the character of the current—whether direct or alternating.

1202. *In inclosed-arc lamps is the inner glass globe perfectly air-tight?*

No; because the cap at the top of the globe is provided with a hole in the center through which the upper carbon can move freely. The downward movement

of the upper carbon is necessary in order that the proper distance may be maintained between the carbon tips to form the arc. The fitting at the top and bottom of the inner globe is very snug, however, and but little air can get in.

1203. *Does the inclosed arc possess any advantages over the open arc besides the lower rate of carbon consumption?*

Yes; the light of the inclosed arc is much softer and steadier than that of the exposed arc and in consequence is much preferable for interior illumination. Comparing Fig. 399 with Fig. 400, it will be seen that the large outer globe used on the open-arc lamp is also used on the inclosed-arc lamp, in addition to the small inner globe which incloses the arc. This makes the fire risk from sputtering carbons considerably less with the inclosed-arc lamp than with the open-arc lamp. On account of the slower carbon consumption in inclosed-arc lamps, the cost of carbons and of replenishing is less. To offset this in a measure, however, are the first cost and maintenance of the inner globes and the additional labor of keeping them clean. Taking everything into consideration, the inclosed-arc lamp is almost always preferable to the ordinary open-arc lamp; it has practically superseded the open arc for indoor lighting and is rapidly replacing it for outdoor service.

1204. *Do the ends of the carbons in an inclosed-arc lamp burn to the same shapes as those of an open arc?*

No; the ends of the carbons in an inclosed-arc lamp burn almost flat, as represented in Fig. 401. This is due to the fact that the carbons are separated farther, which causes the arc, instead of maintaining one position, to shift continually over the ends of the carbons.

1205. *Are arc lamps operated with alternating current different from the others?*

Yes; arc lamps are made especially for that kind of current.

1206. *What effect does the alternating current have upon the carbons?*

It causes both carbons to become equally luminous, and both of them are consumed in about the same time. In the alternating-current inclosed-arc lamp, the upper and lower carbons are at about the same temperature when the lamp is burning, in consequence of which more light is thrown upward than with the direct-current arc. The appearance of the carbons is very much as shown in Fig. 401, but the ends are more flat because the arc travels around the ends of the carbons even more frequently than in the case of an inclosed direct-current arc lamp.

1207. *Of what material are arc-lamp carbon rods made?*

Those for open-arc lamps are composed chiefly of petroleum coke, pulverized and mixed with tar, or a similar binding material, and molded into rods. The rods when dry are baked at a high temperature. Carbons for inclosed-arc lamps of both direct-current and alternating-current types must be made of a much finer quality of carbon because the impurities become vaporized and deposited upon the inner glass globe, reducing its transparency. Lampblack, which is practically pure carbon, is therefore employed. For this reason, and also because they must be perfectly straight and of uniform diameter so they will pass easily through the hole in the cap of the inclosing globe, these carbons cost considerably more than the carbons used in open-arc lamps.

Carbons for alternating-current arc lamps are generally cored; that is, the

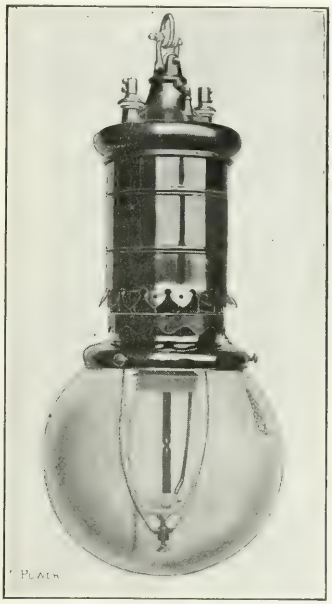


FIG. 400. GENERAL APPEARANCE OF AN INCLOSED-ARC LAMP

carbon rod is formed with a small hole extending through the center of the rod and this is filled with a much softer grade of carbon than the main, tubular portion. In some alternating-current lamps, cored carbons are recommended for both the upper and lower rods, while in others they are used only for the upper.

1208. *Why are arc-lamp carbons sometimes plated with copper?*

Carbon rods used in open-arc lamps are usually given a thin coating of copper to increase their conductivity and make them burn more evenly and for a longer time.

LETTERS

Why "Wrong" Bearing Heats

In the Jan. 2 issue there was an article by J. E. Latta entitled "The Wrong Bearing Heats." Not infrequently, bearings are found to heat without any mechanical reason or explanation for so doing, and much time is wasted in scraping, cleaning and realigning without curing the heating. In many of these cases an examination from the electrical viewpoint has shown that the heating is entirely due to the passage of an electric current through the bearings, which though of low potential may be of very great volume, and this current, passing through the resistance offered by the oil, generates heat. This current is itself generated by the stray magnetic fields from cables or from the field magnet of the machine.

It may be that this is the trouble with Mr. Latta's machine. If so, it can probably be corrected by the insertion of insulating material between the pedestal and the foundation plate, care being taken to insulate the bolts as well as the base itself. This insulating material might readily be composed of very thin paper impregnated with shellac or even without impregnation if the voltage is, as is probable, extremely low.

HENRY D. JACKSON.

Boston, Mass.

I have noticed two or three times the heating described by Mr. Latta; it is caused by the belt being excessively tight. The belt lifts the journal clear off the bottom of the bearing nearest it; consequently the other or outside journal bears only on the outside edge of its bearing. Not having sufficient bearing surface, it naturally heats. If it be possible to scrape or adjust the bearing, with liners to an inclined position, it might then bear for its whole length on the journal; otherwise it will always heat.

W. A. COOIL.

Ladysmith, B. C.

I have had the trouble described by Mr. Latta, and found it to be due to the armature not being centered (endwise) with the field-magnet pole faces. The armature had been put on the shaft too near the pulley end and the drag of magnet poles, in the effort to center the armature, pulled the journal shoulder hard against the end of the bearing sleeve at the commutator end, causing it to heat.

In order to get rid of the heating, I had to raise the commutator end of the whole machine, by means of leather shims under the sliding rail, until the weight of the armature counteracted the pull of the magnets enough to relieve the friction at the end of the box.

A. E. KERNICK.

Madison, Neb.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Annual Convention of Heating and Ventilating Engineers

On Jan. 23, 24 and 25 the American Society of Heating and Ventilating Engineers held its eighteenth annual convention in the Engineering Societies Building, New York City. Headquarters had been established in the building during the year, and as one of the associated engineering societies its first meeting was a record breaker, the registration reaching 250. R. P. Bolton, of New York City, was in the chair and with a large number of papers diversified in character and discussion previously arranged, the convention was a decided success.

On Tuesday afternoon the first session was devoted to the president's address, reports of the secretary, treasurer, board of governors and numerous committees. That added interest is being taken in the society was brought out in the report of the board of governors, which showed an increase for the year of 11 per cent. in the membership, the total now reaching 427. A noteworthy development was the organization of a New York chapter on Oct. 24, the constitution and bylaws of which were approved by a mail ballot and formally recognized at a board meeting held on the first day of the convention.

The secretary's report showed a considerable balance on hand after the heavy expenditures made necessary in fitting up the new quarters of the society.

The president's address on "The Use and Abuse of Fuel" was interesting as may be gathered from the excerpts following:

Use and Abuse of Fuel

The observant heating engineer, traveling over this country, is naturally impressed by the opportunities for the utilization of local materials for combustion, and sometimes observes incongruous conditions accompanying the apparently unnecessary use of coal. In the wooded districts, vast quantities of unused lumber rot on the ground, and along rivers and on the seacoast driftwood and wreckage litter the shores. Such materials are little utilized, though driftwood is sold in New York City at $6 a barrel, and small oak and hickory cut to length bring $16 to $19 a cord.

In portions of the country where peat could be had for the cutting, coal is brought, and I recently saw the waste of a wood-working factory being dumped into a fill, in a mill using bituminous coal at $3.50 per ton.

Natural gas can be obtained at so low a price as 30c. per 1000 cu.ft. even as far away from its source of supply as Buffalo, yet soft coal is being consumed, and ineffectively, with much accompaniment of smoke in that vicinity.

The wastage of one industry or process may be capable of supplying the fuel of a lesser, if properly applied, but it is not to be forgotten that waste materials are possibly capable of utilization in better form than combustion.

In the Northwest, millions of tons of straw and cornstalks are burned locally, and in the South vast quantities of cotton shells and fiber, capable of use either in the production of food materials or paper.

Neglect of one large opportunity is taking place in New York and in many other cities, due to their failure to utilize the waste materials of the community, which are disposed of by common expense instead of being made the means of effective heat production. Under proper furnace arrangements, the rejected ashes, which contain a considerable percentage of unburned carbon, combined with the waste wood and paper, can be utilized effectively with the garbage of a city to contribute more than the cost of the collection in providing power for other purposes. The waste materials of a city the size of Havana would, under proper conditions, afford power for all municipal water pumping and sewage disposal.

The waste materials of the Borough of Manhattan, with a population of approximately 2,300,000 persons, is annually:

Light, inflammable refuse	2,100,000 cu.yd.
Ashes	3,000,000 cu.yd.
Garbage	220,000 cu.yd.

The ashes contain approximately 20 per cent. of unconsumed carbon, representing a heat value equivalent to 168,000 tons of coal. The annual value of the ashes is $504,000, to which may be added $270,000, the cost of disposition at 45c. per yard; this makes a total of $774,000 per annum. This large proportion of wasted fuel is due to the negligent methods of operation of domestic fires, to inefficient settings and proportions of boilers and furnaces, and to ineffective drafts for complete combustion.

There is a final element in the production of coal which should make a special appeal for recognition of the evils of its unnecessary waste. The cost of coal is not paid in money alone, but in an inevitable price of human life and of injury to our fellow creatures. The terrible percentage of the loss of life to the tonnage raised which obtained in the past has been ameliorated only in the mere proportion which the number bears to the increasing tonnage raised, and not in the aggregate. It remains a fact that about 2000 lives are sacrificed each year in the production of the 550,000,000 tons of coal which we partly use and which we partly waste; and that 5000 persons, most of them hard-working men having others dependent upon their labor, are maimed and injured.

In the homes of New York alone, in which upward of 6,000,000 tons of coal are annually burned for the comfort of their occupants, the effect of 3,000,000 tons of which is largely thrown away, the waste represents a loss of 10 human lives, while the annual coal consumption of Greater New York has involved as its share of the annual loss of life 68 persons killed and 170 sorely hurt or crippled. For no other material in common use do we pay so dearly in human life and limb, yet in the use of no other material is so little care exercised, so little relative economy practised, so little educative method followed.

At the close of the reports there was still time for the presentation of two papers: One on the "Heat Exchange Diagram; Its Application to the Theory of Air Washers," by N. W. Akimoff, of Philadelphia, and the other on "Drying Apparatus," by H. C. Russell, of Washington.

Election of Officers

At the evening session the tellers of election reported as follows: president, Prof. J. R. Allen, of the University of Michigan; first vice-president, John F. Hale, Camden, N. J.; second vice-president, E. F. Capron, Chicago; secretary, W. W. Macon, New York City; treasurer, James A. Donnelly, New York City; board of governors, R. P. Bolton, retiring president; Prof. J. D. Hoffman, University of Nebraska; Samuel R. Lewis, Chicago; W. M. Mackay and D. D. Kimball, of New York City.

Wednesday Session

Wednesday afternoon was devoted to a session on ventilation. The following papers were presented: "Ventilating Questions," by D. D. Kimball; "Dust in Relation to Heating," by Konrad Meier; "Effect of Humidity and Means for Control," by J. I. Lyle; "Chemical Notes on Ventilation," by Percy Norton Evans, and a report of the committee on schoolroom ventilation appointed to act in conjunction with a similar committee of the American Association of School Hygiene.

Invitations to attend and take part in the discussion of the papers had been previously issued and a number of prominent physicians from New York City, Boston, Chicago and Springfield, Mass., were present. The doctors, of course, thought that they were the ones to decide on what was necessary and that the engineers were to produce and install the apparatus to furnish the results desired. A great deal of the discussion

hinged on the question of humidity. What was the proper and most healthful percentage? This varied with the temperature, but the majority thought it should range somewhere between 30 and 60 per cent. The entire discussion, however, revealed the fact that very little was known on the subject and that there was lots of work ahead for the society on this interesting and vital topic.

In school work it was reported that many ventilating installations had failed to give satisfaction and in some cases natural ventilation by means of the windows was better than artificial. In the majority of cases, however, this was shown to be due to the ignorance or carelessness of the janitor in the operation of the system.

The committee was continued as its work for the year had been largely preliminary and the various chapters of the organization were urged to take up the work during the coming year with the hope that they would have some interesting data to present at the next annual gathering.

Thursday Session

An informal reception and dinner took place at Murray's on Wednesday evening, and on Thursday both morning and afternoon sessions were devoted to steam and hot-water heating. The following papers were presented: "Steam Heating Large Department Stores; Its Relation to Their Electrical Requirements," by Davis S. Boyden; "Vacuo Hot-Water Heating by Forced Circulation," by Ira N. Evans; "Auxiliaries for Pressure Systems of Hot-water Heating," by J. J. Wilson; "Steam Heating from the Receiver of the Compound Engine," by Auguste Beaurienne; "Heating of a Steam Foundry," by A. M. Feldman; "Heat Transmission with Indirect Radiation," by Frank L. Busey; "Tests of Vacuum Cleaning Tools and Exhausters," by M. S. Cooley; "Definition of the Unit of Heat," by Reginald Pelham Bolton, and "Heating a Swimming Pool," by Cesar Feran.

Due to the number of papers and an extended discussion on amendments to the constitution, only a brief interval was permissible for the presentation of each paper, so that there was but little time for comment or discussion. Such papers as will be of interest to our readers will be presented in this and later issues of Power.

Entertainment

The entertainment program, which was arranged specially for the visiting ladies, included an inspection of the Chelsea docks, visits to the New York Public Library, the American Museum of Natural History, the Metropolitan Museum of Art and to Tiffany's. An automobile ride through Central Park and along Riverside Drive, followed by tea at the Waldorf-Astoria, was thoroughly enjoyed and the program was enlivened by two matinee parties. The Hippodrome was reserved for the last evening of the convention.

Ventilation Problems*

By D. D. Kimball

There is a large group of men who have come to believe that too much emphasis has been placed upon the measuring of ventilation by either the volumetric or CO_2 basis and that such elements as temperature, relative humidity, dust, etc., are of equal or relatively greater importance.

It is unfortunate for the cause of ventilation that many ventilation systems have been produced which have given dissatisfaction, some because of the inexperience of their designers, others because of the interference of the owners or architects in the placing or design of the apparatus; often because of a penurious policy on the part of the owner or architect, which limits the appropriation and thus the capacity of the system; not infrequently because of the poor installation of a well designed system, and very frequently because of a lack of skill in the operation of what would otherwise be a satisfactory system.

It may well be doubted whether it is known today what are the essentials of ventilation; indeed, it may safely be stated that they are not known. Many are the supposed authorities and statements supporting our present ventilation standards, but actually little, almost no, basic or conclusive data or authorities are available which are acceptable to the biologist, physician or inquiring engineer.

Without any attempt to present their relative merits, some of the important features of ventilation now advocated by different authorities are stated below. First in general acceptance in the past, and undoubtedly in the future, may be mentioned air volume. It is only comparatively recently that anything more than a certain volume of fresh air supplied and an equal amount of vitiated air withdrawn was considered essential to ventilation. It cannot now be maintained that this in itself is sufficient to constitute efficient ventilation, but neither can it be denied that this is the basis of efficient ventilation, whether the air be supplied by natural or artificial means. Whether the volumetric standards generally accepted are proper and essential may be open to question and investigation. These standards have as their basis the maintenance of a certain proportion of CO_2 in the occupied apartment. It may be possible that a less volume of air properly conditioned would give the desired results, or conversely, it may be that because of the desirability of air movement or for some other reason a larger volume of air may be required. Herein lies a field for study and investigation by practical means over a long period of time with a large number of subjects, but an investigation involving many difficulties.

Room temperature is becoming the subject of much study. It is said that 70 deg. are too high as a standard for room temperature. Of late 68 deg. have been gaining in favor. There are those who propose to lower the temperature still further. Having dropped from 70 deg. to 68 deg., is there any reason why we should not drop to 66 deg., to 64 deg., or even to 60 deg.? What governs the desirable point or how shall it be determined? It is suggested by Dr. Gulick that possibly there may be an advantage in a methodical variation of temperature; that is, having adopted 68 deg. as a standard, the room temperature should be dropped to, say, 50 deg. for a few minutes, perhaps once in two hours in the case of the schoolroom, the occupants of the room being active during this period. A variation of temperature affects the blood pressure, tones up the system and is known to be helpful in the treatment of pneumonia, typhoid and delirium.

The common demand for comfort may be depended upon to prevent too low a minimum standard, but the effects of too high a temperature, although more serious, are not so quickly noticed or so well understood.

The question of temperature is intimately linked with the question of humidity. Here again there is but little of agreement as to the value or importance of artificial humidification or proper degree of humidification. It may be stated that the normal relative humidity out-of-doors averages around 50 to 70 per cent. with large and frequent variations, and a desert would rarely be found with a relative humidity of less than 30 per cent. It is not uncommon, however, to find schoolrooms, offices and other apartments with a relative humidity as low as 15 to 20 per cent.

It is pointed out that to go constantly back and forth from such a condition to the outdoors with its much higher relative humidity subjects a person to a series of extremes most trying and injurious. In refutation of this statement an able authority points out that outdoor air, when heated in the respiratory tract, becomes just as lacking in relative humidity as the dry air within an apartment.

The nearest to an agreement obtainable on the proper relative humidity is that it should not be less than 30 or over 80 per cent.; 50 per cent. is largely used as the desirable standard, but with

*Abstract of paper read before the American Society of Heating and Ventilating Engineers, New York City, Jan. 24.

what real authority? What harm is done when the frosting of the windows compels a reduction to, say, 30 per cent.? Doubtless there is some one point or some limited range better than another.

With a higher humidity than has been customary in the past one can doubtless adopt a lower temperature, but not with a resulting saving in fuel, as has been stated in public prints. A simple calculation will demonstrate that approximately four times as much fuel is required to evaporate the water required to produce 50 per cent. relative humidity at 68 deg. temperature in the schoolroom as is saved by reducing the room temperature 8 deg. To the engineer designing ventilating systems it would be most helpful if data of acknowledged reliability were available as to the value of humidity and the proper percentage thereof.

Movement of the air is said to have much to do with personal comfort. Persons confined in a limited space without ventilation until the point of discomfort and lassitude was reached because of high humidity and high temperature, or possibly because of the depletion of oxygen in the air, have been instantly revived by the circulation of the air within the chamber by means of fans therein. Undoubtedly a film or envelope of air may form about the body, which, undisturbed by a current of air, will reach a temperature and humidity sufficient to produce serious discomfort. Probably much of the pleasure felt in the summer breeze is due to the carrying away of this body envelope and the tonic effect of the air on the skin.

It is said by some that the heating of air robs it of some vital force, changes it in some mysterious or unknown way, or adds something undesirable to the air, this complaint being especially addressed to steam-blast coils. It may be that a sufficient amount of fine dust containing organic matter will pass through the filter or otherwise reach the steam-heated surface, producing ammonia in harmful quantities, or it may be that some of the oxygen or ozone of the air is consumed by the process of oxidization of the dust.

Ordinarily one thinks of the air as composed of approximately nitrogen, 78.30 per cent.; oxygen, 20.70 per cent.; carbonic acid, 0.04 per cent.; watery vapor, 0.01 per cent.

In reality the air contains other constituents to which but little consideration has been given in the study of ventilation problems. One of these, ozone, is known to be a most active element, and it is now being quite extensively used in the treatment of pneumonia.

In the past a great deal of dependence in estimating the efficiency of the ventilating system has been placed upon the determination of the amount of CO_2 in the air, 6, 8 or 10 parts CO_2 in 10,000 parts of air being regarded as proper standards for hospital, school and factory ventilation, respectively, but since it has been discovered that a person feels no discomfort in an atmosphere containing 200 or more parts CO_2 in 10,000 parts of air if the temperature and humidity are kept within certain bounds, less dependence is placed upon the CO_2 standard and more emphasis is placed upon the need of proper temperature and humidity.

Is it not possible that the full significance or effect of some of the other gases in the air, or the inter-relation thereof, is still unknown, or that there are even other gases still unknown, which in some way or measure may have a bearing upon the subject of ventilation or the subject of air warming? This is essentially a subject of investigation for the chemist or the biologist rather than for the ventilating engineer, but like other problems, it can best be solved by a harmonious working together of the two.

Recent experiments give substantial basis for the belief that the vegetable matter combined with the dust of the air coming into contact with heating surfaces above 160 deg. or 170 deg. distils ammonia, carbon-monoxide and perhaps other gases, in some cases to a harmful degree. It would seem as though this could be best prevented by proper washing of the air or by a limitation of the temperature of the heating surfaces to 160 or 170 deg., or by both processes.

The value of direct radiation, because of the effect of its radiant heat, which is compared to the radiant heat of the sun as desirable and healthful, is a question worthy of serious thought.

The problem of the best method of testing the effect of ventilation and its different elements is not the least of the ventilation problems. The psychological element enters so largely that calorimeter tests or measurement by means of ergographic tests are not generally acceptable. No other acceptable method of measuring the effect of ventilation upon the individual has been suggested.

The method of determining this which finds the most favor is that proposed for the work of the special committee on school ventilation in which it is proposed to take one or more large school buildings occupied throughout by children of the same grades and condition, treating one-half of the building in one way and the other half in another way, carrying on the treatment for a period of months and measuring its effect by the relative standing of the pupils and their relative condition as to health, weight, etc., as described in the report of that committee.

Briefly summarized the phases of ventilation now believed to be worthy of serious study are as follows:

Volume of Air—The present standards are questioned. By a proper study of temperature or humidity could they be decreased or should they be increased?

Temperature—The present standard (68 deg. for the schoolroom and home) is said to be too high. Shall it be lowered and, if so, to what point?

Variation of Temperature—A periodical reduction of temperature is said to be desirable.

Humidity—Is artificial humidification of occupied apartments desirable, and, if so, to what degree?

Movement of Air—This is said to be desirable. When can it be employed and to what extent can it be carried without involving injurious drafts? What of a frequent "flushing out" or perflation?

Heating of the Air—May the air be harmed or in any way affected in the process (assuming the air to be free from dust)?

Cooling of the Air—Is this desirable in occupied apartments and will it involve undesirable attending features?

Dust—It is stated that dust is extremely harmful. What is its effect, how best eliminated, and how generally should such means be employed?

Organic Matter from the Breath or Body—What is its nature and effect?

Chemistry of the Air—Is there anything connected therewith worthy of further investigation? What of ozone?

Relation of ventilation to exercise and work.

Methods of determining the effect of ventilation and its different elements upon the individual.

Although many of the so called failures of ventilating systems in the past may have been due to inexperience of the designer, and many more were doubtless due to lack of skill in operation, it is believed that much of the condemnation of artificial ventilation heard from eminently reliable medical authorities and others is due to the failure of the ventilating engineer to give as much attention to the conditioning of the air as to its volume.

It cannot be denied that the engineers are providing ventilation fulfilling the existing standards, but these standards are not of their creation but were given them by biologists, physicians and scientists in the past. Questions of the percentage of oxygen required, percentage of CO_2 permissible, effect of temperature and humidity, question of organic matter in the air, etc., are not engineering questions. It is but the duty of the engineers to meet those standards which are demonstrated and given to them by the biologist, physician and scientist.

If, therefore, the apparatus provided by the engineer has failed to give satisfaction it is not that the apparatus or engineer has failed but because the

standard provided them has failed. If this is a fact, the biologist or physician should determine wherein the existing standards are wrong and they should determine new standards supported by authoritative tests and experiments. Then the engineers may be trusted to provide ventilation fulfilling the new standards.

Heating a Swimming Pool*

By C. Teran

A swimming pool is generally a luxury, not a necessity. For this reason not many are built, and a description of the system installed for Herbert Coppell at Tenafly, N. J., may prove of interest.

It is housed in a building of one story, and includes the pool room, two dressing rooms, boiler and coal rooms, all on the ground level. The pool is sunk below grade, is built of concrete, waterproofed and lined with English size enameled brick. It is 38 ft. long, 15½ ft. wide and 6 ft. mean depth below water level. The cubical contents are, therefore, 3534 cu.ft.

The heating plant was designed to heat this volume of water in 10 hr., or at the rate of 353 cu.ft. an hour. Ten hours is a convenient length of time for heating the water, because the required apparatus is not specially large. If the apparatus was much smaller it would, of course, require a longer time to heat the water, and this time added to that necessary to empty and clean the pool would make the period of time which the pool would be out of commission too long. The time required to empty and clean this pool is 4 to 5 hr.

The installation includes two cast-iron sectional boilers, a Berryman service heater and a filter. The water is reduced to 30 lb. pressure on entering the building. It is then heated in the Berryman heater by steam generated in the boilers, and then filtered and discharged into the pool. For filling, a main inlet is used; this enters the pool at the deep end near the bottom; there is also a nozzle above the water line which is used to produce a spray over the pool.

On account of the proximity of the walls of the pool to the outside ground a loss of heat in the water was anticipated and provision made to replace the loss. Careful consideration was given to the various methods that could be used to accomplish this purpose, and injecting water heated to a high temperature into the filled pool was decided upon. The reason for using a high temperature is that the water is not taken from the pool to be reheated, as this would necessitate a circulating pump, but fresh water is used, and by heating it to a high temperature a minimum quantity of water is required and less coal burned. The water is injected at four points on each side of the pool near the bottom, through nozzles passing through the brick lining and flush with it. This arrangement gives a good distribution, and is neat in appearance. It is found that during the winter months the water loses 2 to 3 deg. F. in 24 hr.

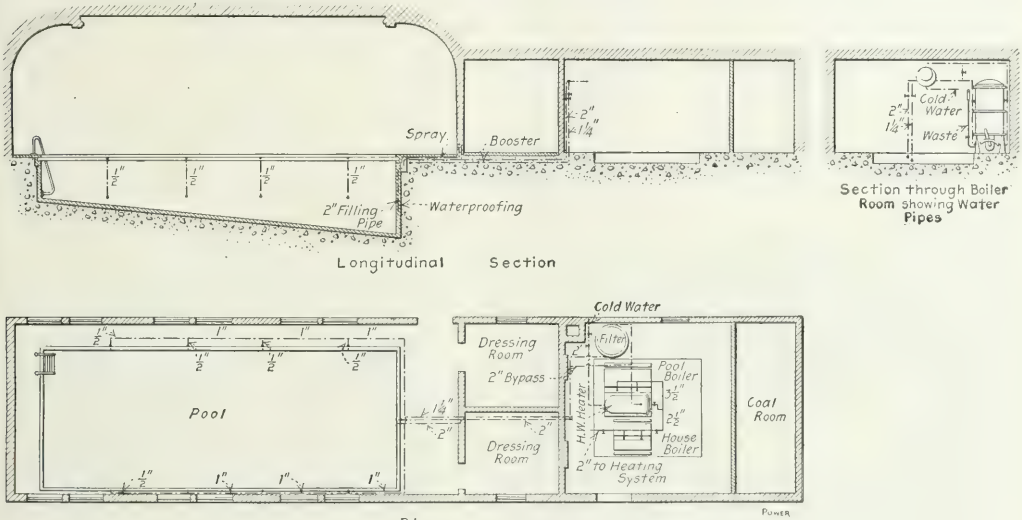
In filling the pool the water is heated to 75 deg. F., which, on account of heat losses in transit, etc., gives an ultimate temperature of 70 deg. F. The water injected to make up the heat loss is heated to 180 deg. F.

The large boiler is used to heat the water when the pool is being filled. This was computed as follows:

Contents of pool	3534 cu.ft.
Water to be heated per hour	353 cu.ft.
Water to be heated per hour	353 × 62.4 = 22,027 lb.
Rise of temperature of the water	40 to 75 = 35 deg.
Heat units transmitted to water per hour, 22,062 × 35	771,000 B.t.u.
Coal necessary to be burned per hour, 771,000 ÷ 8000	96 lb.
Grate area, 96 ÷ 8	12 sq.ft.

A boiler having a grate 40 in. wide by 48 in. long was installed. The other boiler shown is used to heat the building and the water injected into the pool to make up the daily loss of heat; by this arrangement, the necessity of keeping a fire in the large boiler is avoided. As there was no sure method of predetermining the loss of heat of the water in the pool, in selecting this boiler liberal allowance was made for this purpose above what is required to heat the building. The amount of direct radiation is 400 sq.ft., all behind screens; the boiler is rated at 1000 sq.ft. and has a grate 21x27 in. or about 4 sq.ft.

The service heater was specified of proper size to heat 2800 gal. of water per hour from 40 to 80 deg. F. with low-pressure steam, and it was left to the manufacturers who furnished it to design the proper size heater for this duty. The filter was specified in a similar manner. No automatic temperature control was installed, and none has been found necessary. An even temperature of the water is attained by maintaining a steady fire and regulating the flow of water by hand.



Plan and Elevation Showing Piping Connections to Pool

*A paper read before the American Society of Heating and Ventilating Engineers, New York City, Jan. 25.

Corrugated Film Boiler Feed Water Heater

Among the specialties recently brought out by the Schutte & Koerting Co., of Philadelphia, is what is known as the spiral corrugated film feed-water heater, views of which are shown in Figs. 1 and 2.

The principal features of this heater lie in the concentric spirally corrugated tubes, which construction, besides constantly agitating the water and preventing the formation of cold cores, keeps the water in a thin film between two heated surfaces, thus making a combination that should give an exceedingly high rate of heat transmission.

In Fig. 1 is illustrated the arrangement of the corrugated tubes in the heater and also the path of the water between the two corrugated surfaces. The outer tubes are expanded into headers, and the inner tubes are then screwed into place and the outer joints made tight by nuts which are securely locked. This construction is shown in Fig. 1.

All expansion and contraction of the tubes due to heating and cooling is taken up by the floating header, which is free to move endwise. This feature reduces the possibilities of leakage to a minimum.

The steam enters through the opening in the center of the shell and passes through small holes which are drilled in the shell and act as a baffle-plate, thus preventing a direct jet of steam impinging upon the tubes. The steam is therefore distributed about the outer tubes and inside of the inner tubes, the condensed water draining off through the opening at the right-hand bottom end of the shell. The feed water enters at the bottom of the end connection, shown in Fig. 1, and passes through the film formed by half the tubes to the floating header, and then through the other half of the tubes and out at the top opening shown at the end of the sectional view. These heaters are made in 16 sizes in both vertical and horizontal styles.

Fig. 2 shows an end view of a heater and the manner in which the heads fit in the outer casing.

Howard Ball Valve

Perhaps there is nothing in the power plant which is so misused as the blowoff valve; it is often hid away in a most inaccessible place and it is frequently neglected and abused. For these reasons, and because of the severe character of the service which it must perform, a successful blowoff valve must be simple and rugged.

The accompanying illustrations show the Howard Ball Valve for blowoff and other services where ordinary cocks are used. A hollow ball of bronze with openings at opposite sides fits into a suitably formed body of the same material. The ball is turned by means of a box wrench which fits over the square head of the stem. A quarter turn opens the valve full or closes it tight. The valve is kept tight by means of suitable packing which is fitted into a recess in the discharge end and retained there. Thus,

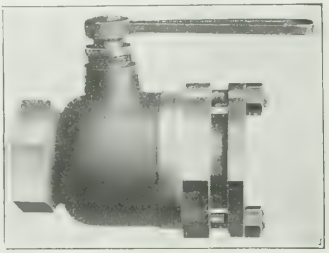


FIG. 1. THE HOWARD BALL VALVE

this packing is supported on three sides by bronze.

The principal feature of this type of valve is the fact that there is no metal-to-metal friction as the ball comes in contact with the packing only. Thus wear is reduced to the minimum and the life of the valve is greatly increased. It is claimed that under very severe conditions it is necessary to repack the

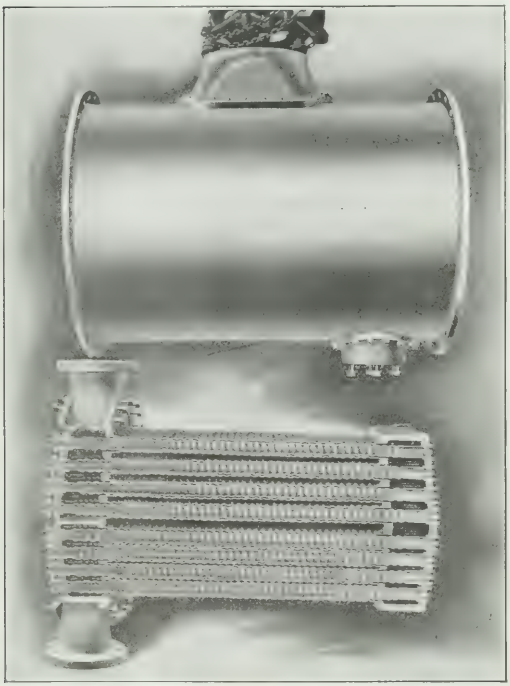


FIG. 1. HOW THE TUBES ARE ARRANGED

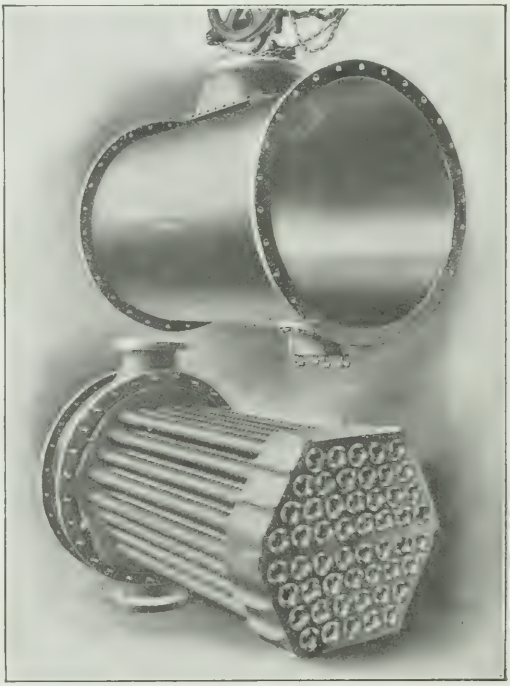


FIG. 2. END VIEW OF TUBE HEAD

valve about once a year, and under more favorable conditions, less frequently.

Some of the other points of superiority claimed for this valve by its manufacturers, the Howard Iron Works, Buffalo, N. Y., are as follows:

It is made entirely of special bronze, there is no chance for the metal to corrode or be affected by boiler or other injurious compounds. All valves are

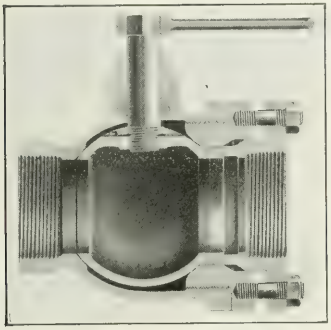


FIG. 2. SECTIONAL VIEW

made for a working pressure of 300 lb. and the fitting is designed to withstand strains due to water-hammer. Because of its construction, the greater the pressure, the tighter the fitting becomes. As the valve has no complicated adjustments, there is nothing to get out of order, and it does not require the attention of an expert to keep it in good condition. It is impossible for the valve to stick, and no sediment can lodge in it. The valve is easily operated even under high boiler pressure; it offers the full area of the pipe opening, when open, and the passage is straight through, thus preventing the accumulation of foreign matter. Sediment cannot affect the ball and the seat is self-wiping and cleaning. The large bearing surface of the valve is made for durability. The packing can be easily, quickly and cheaply renewed.

Improved Furnace

An improved furnace has recently been patented and assigned to the Parson Manufacturing Co., 149 Broadway, New York City. It is illustrated in Figs. 1 and 2, the first showing a front elevation, and the second a side elevation.

The fuel is introduced into the furnace at the front, in which an arch is constructed. The fuel-feeding mechanism consists of one or more hoppers, each of which is supplied with a fuel pusher consisting of a movable platform loosely interlocked, and given a reciprocating motion by an eccentric carried on a shaft in front of the boiler setting.

By means of suitable angular displacements of the eccentric, the pushers can be operated at predetermined intervals. The shaft carries a ratchet wheel which is actuated by a pawl carried on a rocker-arm attached to a reciprocating rod. This pawl permits a close adjustment or regulation of the angular motion to be given to the shaft.

Fuel is discharged from each feeder unit upon the platform set under an arch in the front wall of the furnace where the layers of fuel can receive the full heat of radiation.

The layer of fuel is first coked on its inner or advancing edge and then pushed beyond the plate or platform, where it breaks off and drops in a broken state upon the hearth below.

This mechanism consists of a frame having a chain grate running upon sprockets and actuated by a ratchet and pawl mechanism. The grate-frame casing for the greater part of its length toward the rear is closed at the bottom so as to form a channel in which the grate bars on their return convey the ash deposits from the rear to the front of the ashpits. At the back of the furnace there is an inclined grate hinged at the back and resting upon the chain grate, thus forming a part of the hearth surface.

Back of this there is a movable dumping grate that can be moved into a recess in the bridge-wall. The inclined grate guides the ash and unconsumed fuel upon the dumping grate, where the accumulation effects a seal against the bridge-wall. The incline and the dumping grates may be perforated for the admission of air so that combustion may take place on them and thus form additional active hearth surface.

At the front of the grate beneath the dead plate is a hinged apron which rests upon the grate bars or upon ashes covering them. The apron extends some distance within the furnace beyond the edge of the dead plate, and the fuel is coked and dropped upon the extension of the apron; the coking is completed there and the fuel is then drawn off upon the grate bars as they move toward the rear.

At one side of the furnace there is a small ash conveyor which takes the ashes from the bottom of the ashpit to the grate under the apron and deposits them upon the grate as it travels toward the end of the furnace. Although a certain amount of ashes drops through the grate opening, the artificial application of ash to the grate, and the usual rate of feed may be such as to purposely cause an accumulation of ashes upon the dumping grate against the bridge-wall. Here it will normally be maintained until it becomes excessive, when this surplus is conveniently discharged by withdrawing the dumping grate.

The ash acts as a seal at the front and rear of the grate, which causes the air supplied to the ashpit to pass up through the grate. The fuel passes slowly through the combustion area resting on the layer of ash deposit.

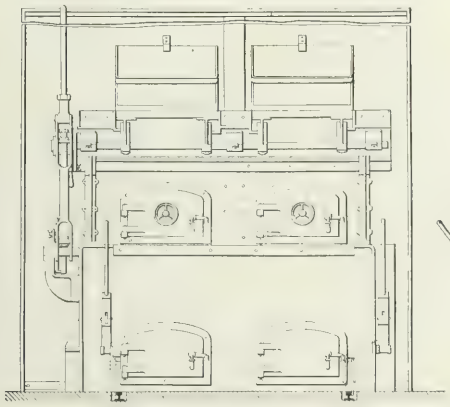


FIG. 1. FRONT ELEVATION

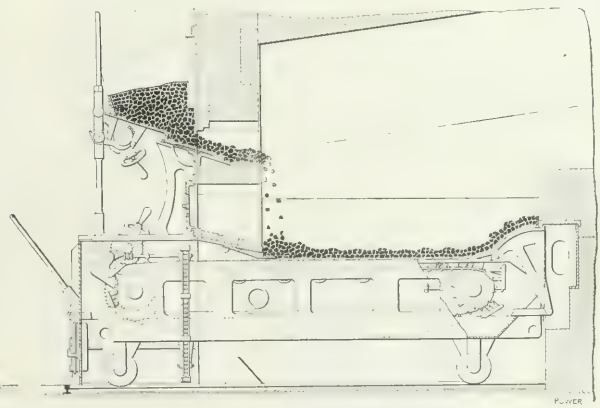


FIG. 2. SIDE ELEVATION OF THE IMPROVED FURNACE

Oster Bent Pipe Threading Machine

The increasing use of bent pipe for conduit and other purposes has created a demand for a pipe machine which will thread pipe when so bent. Such a machine, shown herewith, is developed by the Oster Manufacturing Co., Cleveland, Ohio.

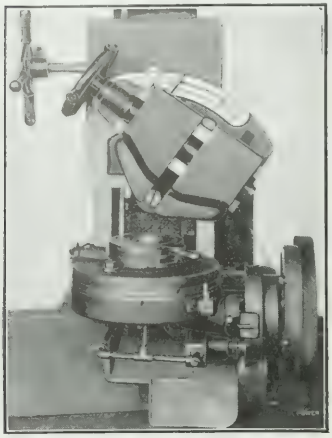


FIG. 1. TOP VIEW OF BENT-PIPE THREADING MACHINE

Fig. 1 is a view looking down on the machine. The swivel vise will stand at any necessary angle to thread pipe bent on a radius from 6 to 24 in. This vise is locked in position and the pipe is held in its jaws in the ordinary manner. The slot in which this lock is placed is so graduated as to enable the operator to place the vise at any desired angle.

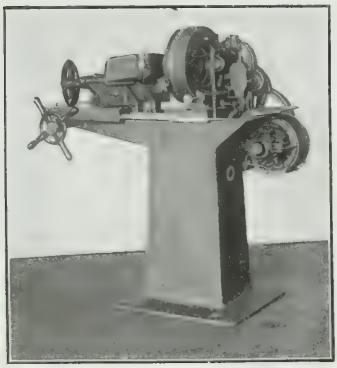


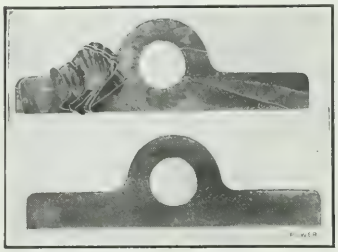
FIG. 2. SIDE VIEW OF PIPE-TRHEADING MACHINE

When threading straight pipe, the vise is locked in its normal position, and the machine becomes an ordinary pipe-threading outfit, good for all job purposes, even to threading pieces as short as 3 in. without the use of any special nipple jaws. The machine is also equipped with an automatic knock-off so that threads of a standard length can be easily made.

The present line of machines is developed up to 2-in. pipe only. Special machinery will, however, be made to order up to and including 6-in. pipe.

Shim for Bearings

The halftone shows a new and remarkably clever shim, composed of a series of layers of brass 0.002 in. thick, firmly held together by a film of solder of no appreciable thickness. Adjustment is made by lifting one end of one or more of the layers and peeling off. The rest of the shim remains as solid as



LAMINATED SHIM

ever after the layers are removed. This shim is applicable to all classes of machinery where split bearings are used. This metal can be obtained in sheet form and cut to suit. It is manufactured by the Lindhe Shim Co., New York City, N. Y.

United States Overfeed Stoker

Under date of Jan. 2, page 24, a description of this overfeed stoker was published, in which it was stated that a continual stream of water passes through that portion which is in direct contact with the burning fuel. This statement was the same as submitted by the makers, who request us to make this correction. The circulation of water is very rapid and intermittent, being under control of a check valve. When the grates are started in operation the check valves are opened; as soon as the water has flowed in and filled the grates this check valve automatically closes, preventing the inflow of any more water until that which is lying in the grates is flashed into steam. When this flashing takes place all of the steam and water in the grates is flashed very rapidly into the steam space of the boiler, carrying with it any foreign substance in the tubes that are cast in the grates. As soon as this flashing takes place the check valve is again opened and a fresh supply of water taken in. The flashing is very rapid, taking place at intervals of about eight seconds when the stoker is in operation.

Important Boiler Tests

To determine the comparative merits of the Jacobs-Shupert sectional firebox and the ordinary type of stay-bolt firebox for locomotive boilers, a comprehensive series of tests are being conducted by Prof. W. F. M. Goss at the Jacobs-Shupert Co.'s works at Coatesville, Penn.

Three distinct groups of tests are to be made. The first consists of tests to determine the relative amounts of heat absorbed by the fireboxes of the two boilers under similar conditions of operation. The original construction of each boiler provides a diaphragm which separates the water space into two compartments, one including the tube surface and the other the firebox surface. In the course of the tests these compartments are to be fed separately with weighed water, an arrangement permitting a separate determination of the heat transmitted by the firebox and by the tubes respectively. These tests will also show the relative heat-transmitting capacity of a unit area of firebox-heating surface as compared with a unit area of tube surface.

The second set of tests will be made with the diaphragms removed. It is also expected that information will be secured concerning the circulation in the boilers.

After the completion of the foregoing tests the boilers will be removed to a location where their explosion will result in no harm to surrounding property, and are to be tested for strength under low-water conditions. The instruments of observation are to be placed within shelter and all precautions are to be taken to insure the safety of the spectators. Under these conditions each boiler is to be subjected to a progressive series of tests until the destruction or serious deformation of the firebox occurs, the series to be carried out substantially as follows:

The boilers are to be operated under normal conditions at a predetermined rate of power and the feed is then to be cut off until the water level reaches the upper surface of the crown-sheets. The feed pump will then be started again and the water level restored, after which the pressure will be reduced and a careful examination made of all parts. This will be repeated, lowering the water level successively 1, 3, 6 and 12 in. below the crown-sheet.

In order that the fire may be under control at all times at a safe distance, oil fuel has been selected.

The Jacobs-Shupert United States Firebox Co. has announced that it will be glad to have any engineers interested present at the tests.

The first of the tests was begun on Feb. 1 and the low-water tests are scheduled to begin about Apr. 1. The exact dates, however, may be had a few days in advance by applying to the above mentioned company at Coatesville, Penn.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Secretary Fisher on Water Power Development

The annual report of the Secretary of the Interior, which has just been made public, shows an intimate knowledge of the present conditions affecting water-power development in the United States and points out a course whereby the present chaotic situation may be eliminated and still preserve both Federal and states rights.

The inadequacy of the provision now included in Federal grants, making a tenure revocable at the will of the administration, is pointed out. This theoretically tends to increase the risk involved and gives an excuse for demanding unusually large returns upon the investment, in spite of the fact that experience has shown no such risk to exist. Furthermore, such a provision tends to discourage water-power development.

Mr. Fisher is of the opinion that the Federal Government has ample constitutional right to control the water powers both on navigable streams and upon the public domain; in fact, Federal control is often necessary where long-distance transmission involves interstate commerce.

Summed up in a few words, the report recommends that the Government lease water-power privileges upon the payment of rentals which shall be adjusted at periodic intervals. When the period of readjustment arrives the Federal Government will inquire into the condition of the grant, and if the grantee has been furnishing good service at reasonable rates and making a fair profit, there will be no reason for raising the rentals. If, on the other hand, the grantee has been permitted to make an unduly large profit at the expense of the community, the Federal Government can increase the rental and thereby indirectly reimburse the public.

The question of fixing rates and regulating service is to be left entirely to the state or community and all returns from rentals of the power sites are to be used in improving the flow conditions or for other local improvements. In this way the benefits are to revert to the state.

The argument that rentals must necessarily increase the price paid for power by the consumer, is answered by pointing out that most towns supplied by hydro-electric power also have steam-generated power, and that the cost of producing the latter will necessarily fix the selling price of all the power.

Heretofore, the absence of any definite policy has resulted, in some instances, in the granting of special privileges contrary to the best interests of the people, while in others it has hindered the development of important water powers. Now that the Federal Government has signified a willingness to do its part and has outlined a tentative plan, it is time for the states to step into line and offer their earnest coöperation.

Valves in Steam Lines

In a broad sense, valves in a steam line may rightfully be considered as a necessary evil. This statement is rather startling at first thought, but when all of the difficulties, disadvantages and dangers in connection with their use are fully realized the truth of the statement will be well appreciated. Of course, some valves are always necessary, but the number should be kept at a minimum. Stop valves on the boilers, as well as a valve at the junction of each branch to the main line, are always indispensable, but often additional valves are inserted at various points merely to cut out a part of the steam main. Such valves are usually superfluous and are more detrimental to the system than otherwise.

The greatest disadvantage resulting from a multiplicity of valves is, perhaps, their obstruction to the flow of the steam. This engenders a drop in pressure between the boilers and the steam consumers which means a certain efficiency and, therefore, a monetary loss day after day as long as the plant continues to operate. For this reason such types should be installed that offer the least impediment to the free passage of the steam.

Attention should also be given to the question of condensation and, where necessary, the valves should be properly drained to prevent the accumulation of water which might be picked up by the onrushing steam and perhaps result in a blown-out cylinder head or other damage.

Another disadvantage of a multiplicity of valves is their constant care in keeping the packing tight. Any leaks due to poor or loose packing can be easily noticed and repairs made at once, but wire drawing and internal leaks are not so noticeable and they sometimes lead to considerable trouble and even danger. For instance, if there are two valves closed and the one nearest the boiler allows steam to leak through while the other one is perfectly tight, the steam pressure will build up in the line between these two valves and become a source of danger, particularly as such a condition is usually unexpected and, therefore, not provided for.

The proper, accessible location of the valves should always be borne in mind when laying out a steam line. In many plants the question of proper valve location has been so little considered that his life is endangered every time a man essays to close one, for should there be an escape of steam while he is operating the valve, he would either be scalded or have to take big chances and drop to the floor. Oftentimes a small platform is built directly over the steam line to which the valve stem is carried. This is a poor arrangement for in case of accident there is no possible way for the man to escape as he would be in the direct path of the steam rising from the break in the line below.

The placing of valves in pits should also be avoided; if it is absolutely necessary to do so, then the valve stem should always be extended to the floor level above, from which point the valve can be closed or opened without any danger.

Ventilating engineers complain that their work is hampered by the interference of owners of buildings and architects. Operating engineers can sympathize with them. Until steps are taken to prevent this ignorant interference, fool managers will continue to rush in where wise engineers tread with extreme caution.

How the Central Station Got One Plant

The engineer looked over his plant and was proud of it. For years he had been chief over nine or ten men who were doing work that could easily have been done by six men.

So far as the chief knew, the central-station solicitor had never dreamed that there was a chance to do business with the owners of this plant. But Mr. Solicitor was merely biding his time, and his time finally came, much to the surprise of the engineer.

This chief is an every-day, ordinary engineer, just like thousands of others who work in large cities. He had allowed his boilers to become dirty, the tubes were covered with scale and the efficiency of his plant ran behind in other respects. One day the inevitable accident happened; the entire plant was shut down and things were at sixes and sevens. Current for light and power was in urgent demand.

Here was the chance for which the central-station solicitor was waiting; he could put in motors and electrical connections in a few hours, and he did. The engineer had his excuses ready as to the cause of the accident, but the thing of the greatest moment to all concerned was that the central station had gained a foothold, with the probability that its service would remain in that plant, and that the engineer would have to go.

And he did; he is now looking for a position. The central station is changing all of the useful steam-driven machinery to motor drive, and many of the old machines are being removed and discarded; useless lengths of piping are being taken away, and one of the two boilers has been condemned. In a short time this plant will be electrically equipped throughout, and the chances are very strong that the central station will remain as the dominating factor in its operation.

The story has been told—nothing added, nothing withheld—and there is but one conclusion to reach: The engineer of that plant was inefficient; he either did not know his business or he was blind to his opportunities and to his own interests. He lay back, took things easy; in fact, sold his birthright for a mess of pottage.

How many more are there like him?

"To Earn More, Learn More"

"Learning while getting a living" is the headline on a newspaper story of how some young Westerners do both while paying their way in college and acquiring industrial knowledge in a shop. And there are 500 applications for 150 vacancies in the freshman class this term. "To earn more, learn more."

A five-ton fire engine recently did duty on the streets of New York sandwiched between two huge placards warning people against throwing away lighted matches. This may seem spectacular, but it drew an attentive crowd. It might be well to mount the next exploded boiler on a four-horse truck and draw it through the streets placarded with the cause of the explosion. Perhaps it would decrease the number of boiler accidents.

The New York physician who said recently that there is no such thing as artificial ventilation seems to agree with the college professor's celebrated lecture on the snakes in Ireland: "There is none." If the medico will revise his opinion by stating that in his hospital practice he has not always met with the best of ventilation, he will appear to agree with many of the ventilating engineers.

POWER is in receipt of a number of articles on "Running a Steam Turbine," but more are wanted. Send in a clear, brief story of how you would run a steam turbine; illustrate it with rough sketches. The editors will put the article in shape, if necessary, and the artists will attend to the drawings. You may win the fifty-dollar prize. Turn back in your file to Dec. 26 and study the conditions of the contest.

Old steam boilers under sidewalks are a menace to the public which the boiler-inspection department of New York City is supposed to safeguard. Better put some of them out on the scrap-heap.

If your employer still believes that the beginning and end of your vocation is keeping the water boiling, it is probably your own fault. It may be that this is the reason why he turns a deaf ear when you want more money.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Sampling and Analyzing Coal

When samples of other than small coal are to be taken, some difficulties arise which cause considerable work. The sample should be a fair specimen of the coal in general, and fair to both dealer and consumer.

With one engineering firm it was customary to tell the coal agent that an analysis of the coal would be made and if the contract was let the coal delivered must be kept up to the analysis. The agent, to be obliging, would send as a sample a lump of coal that would grace a mineralogist's cabinet but be absolutely useless for analysis, or a letter of introduction would be given to some consumer who out of courtesy would insist on getting the sample from the coal-pile himself, which would be equally ill fitted.

If the coal to be tested was lump coal and in the car the sample was taken while the car was being unloaded; if one of the smaller grades, the sample could be taken by digging along the sides and middle of the car, straight down to the bottom. If taken from the boiler room I usually managed to be there while the coal was being delivered and thus got a sample from the pile as well as from the wagon. The amount varied with the size and the condition of the coal. For lump and block more was taken, until a sample containing a fair run of the coal was obtained. If the coal showed seams of slate the pile was thoroughly gone over to estimate about what percentage of the lumps contained slate. The sample was then placed in a pile and mixed, broken into pieces about 3 or 4 in. square and the pile quartered. Opposite quarters were taken and the process continued until the coal was broken into pieces about ½ in. square. For taking the coal to the laboratory a tin pail holding about 5 lb. and fitted with a tight cover was used.

In the laboratory the coal was again broken into pieces of about ¼ in. and exactly 5 grams weighed and placed in the oven at a temperature of 225 deg. F. for one hour to expel the moisture. Up to the time of placing the coal in the oven the work was done as rapidly as possible as in breaking the coal more opportunity was offered for the loss of moisture. A fair sample of the coal in the bucket was taken and ground in a Parker mill and 2 or 3 oz. pulverized in a mortar till fine enough to pass through a 100-mesh sieve. This is mixed and quartered and about 1 oz. retained for the final analysis of volatile matter, fixed carbon and ash. Two tests are made by which to check.

The calorific value of the coal was found with a Parr standard calorimeter for B.t.u. per pound of coal, for the B.t.u. per 1c. and the B.t.u. per pound of hydrocarbons. From these readings calculations were made to determine the heating value of the coal as it was delivered, with the moisture still in it, and also on the coal with the moisture expelled. The third calculation was for pure coal; that is, coal containing only volatile matter and fixed carbon.

The difference between the B.t.u. per 1c. for dry coal and wet coal shows how much can be lost by a fireman continually wetting the coal. The tests made were for coal used in 18 or 20 buildings and were made without notice to the engineers or firemen, but when the log sheets showed the manager that the coal was falling off in quality.

The report of the analysis was made on a card similar to the one shown and filed for reference.

Name of coal....
Location of mine
Name of dealer
Date of test
Price per ton
Sample from

	Wet	Dry	Pure
Fixed carbon			
Volatile matter			
Moisture			
Ash			
Total			
B.t.u. per pound			
B.t.u. per 1c			
B.t.u. per pound of hydrocarbons			

REMARKS:

THOMAS H. WATSON.

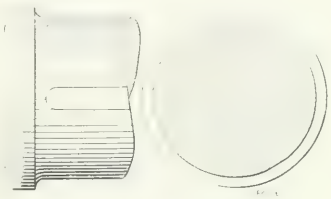
Chicago, Ill.

Cure for a Hot Bearing

A short time ago, one of the main bearing journals of a large Corliss engine under my charge gave considerable trouble by warming up.

Many and various remedies were tried for preventing it without any real success until I happened to tell my troubles to a neighbor engineer who gave me a cure for hot bearing journals which, when applied, proved successful and stopped further bearing troubles.

The cure consisted of cutting three flat places along the shaft as shown by the accompanying sketch. This method, I was told, was a common practice among old-timers in Lancashire 30 years ago. My friend had it down to a standard, the flats being made ⅛ of the shaft diameter wide and the lengthwise cut was within ⅛ of the shaft diameter of the journal ends. That is, for an 8-in. diameter journal, the flats should be 1 in.



FLAT PLACES ON THE SHAFT

wide, and extending to 1 in. of the journal ends.

My friend also said that this method was applied on new machinery made in the north of England about this time. Is there any reason why it should not be adopted today?

F. P. STRACHAN.

Belfast, Ireland.

Sheet Packing and Gaskets

The two principal points regarding a good packing job are the cutting of the packing and the putting it into place; after that comes the quality of the packing. Have the packing as thin as possible; $\frac{1}{32}$ and $\frac{1}{16}$ in. are best, though ⅛ in. is good in some places.

Do not load up on all the varieties made, even to please a salesman, for just as sure as this is done the waste will grow proportionally. One salesman will advise a red packing and another black, and both will prove that they are right. Because a packing tears easily in the hand is no real proof of its poor quality.

Do not buy packing suitable for superheated steam for medium steam pressures, 100 lb. and less, because it is a waste of money. In cutting sheet packing into gaskets for flanges, steam and water cylinders, steam chests, etc., use the knife more and the hammer less. Under equal conditions, a poor quality of packing cut with a knife will give better satisfaction than a better grade cut with the hammer in the flange. Do

not be afraid to use the dividers, rule and pencil in laying out packing.

It is all right to place the packing against the flange and tap it lightly with the hammer for marking, but on no account hit sufficiently hard to cut the gasket; use the knife for that, as the hammer tears it. To save time, men will sometimes cut the bolt-holes out with the peen end of the machinist's hammer. This is bad practice and is the cause of many blowouts at the bolt-holes.

Never place one gasket on top of another to make a tight joint. If the flanges do not face properly, a gasket will not answer the purpose. That is what a "dutchman" is for.

As to what constitutes a good sheet packing or gasket, here is an instance that will verify what I stated at the beginning of my letter, it depends upon the one putting it in: The valve in question was a 3-in. globe valve, the steam supply to a fire and general-service pump of 750 gal. per min., and using steam at 80 lb. pressure.

This pump runs 24 hours a day for about six weeks, when its companion takes the next shift, and they have both been doing so for 12 years.

It was necessary to remove the valve bonnet to replace the valve disk; and this was the first time it was removed in all that period. The gasket on it was a single loop of common cotton string, the ends simply crossing one another in the form of an "X."

Equally as important as cutting the gasket and putting it in place is the coming up on the bolts with the nuts. It is understood that the faces of the flanges are thoroughly cleaned for this operation.

Just watch a first-class engineer come up on the bolts on his engine cylinder head or steam chest when replacing them. Note how carefully he comes up on them all, little by little, paying particular attention to each one in turn as the task is nearly done. One or two bolts are not put under a severe strain while the rest are being brought up to proper tension, but the pressure is divided equally and gradually on them all. The inclination to come up tight first on one bolt, then follow with the next, and so on, is the cause of many blowouts at the bolt-holes. The cheapest part about any gasket is its original cost; putting it in is the expensive part. Graphite mixed with cylinder oil is an old and excellent thing to apply to the face of one of the flanges, so the valve bonnet or steam chest may be easily removed without destroying the gasket.

Many users of sheet packing call for packing with cloth insertion for cold-water service, but equally good results may be had of packing without it, as well as saving the expense of an extra line of packing. Watch the dollars; packing runs into dollars very quickly.

A noticeable fact is that nearly every time an expert—one of the maker's own men sent to make good a machine or appliance—has a job of this kind, especially on engines and pumps, and either end of the latter, he seems more anxious to get heavy wrapping paper for gasket material. As these men are working on their companies' own time, they must certainly know what is best both for service and lasting qualities. Salesmen have actually laughed at such absurd purchases as ¼-in. thick sheet packing, and say that there is absolutely no gain in its use. Of course, diaphragm packing requires a special packing.

An excellent tool for cutting bolt-holes in a gasket is a punch made of a short piece of pipe having one end ground to a sharp edge. Place the gasket on a board and hit the punch with the hammer. It is best to have a set of these punches to suit the various size bolt-holes needed.

By using ring gaskets there is certainly a saving on material. The average mechanic in using sheet packing wastes a great deal of it, and instead of using the scraps, which at times are amply large for small work, he will hack off a generous piece from the roll and in turn add to the junkpile. Make sure the gasket is a good fit, no crimping in it; see that the bonnet or flange fits even and comes up uniformly on the bolts, and a good job is assured.

SCOTT NORTON.

Springfield, Ohio.

A Deranged Governor

I had an interesting experience some years ago down in western Tennessee, in a small lighting plant; the engine was a small high-speed affair and it was giving trouble from racing.

I had been sent for to indicate the engine and try to locate and remedy the trouble. When I arrived at the plant, at about 9 p.m., the superintendent was at the switchboard and the engineer at the throttle valve, trying to maintain sufficient light to "pull off" a show which was in progress in a theater of the town. After midnight we shut the engine down to ascertain the trouble. I found only one governor weight on the engine, and asked the engineer where the other one was. He said it was over in the corner; they had tried the weights every way they could think of and got better results without the other one. I looked the engine over and found the eccentric to be only about 30 deg. ahead of the crank. At this I was not surprised, but when I discovered that the eccentric was keyed to the shaft in this position I began to wonder, for I knew the engine had previously run in a power plant at Nashville, Tenn., and was bought by these people second-hand.

I asked the engineer if the eccentric was keyed to the shaft when they got it and he informed me that it was. I then asked if they had made any repairs on the engine; he informed me that a local machinist made a new crank disk for the engine.

This, of course, made matters clear, for I knew then just what had happened. The machinist who repaired the engine paid no attention to the position of the keyway in the old disk, or to the relation of the eccentric to the disk when he came to cut the new keyway, but just cut it any place that came handy. Fortunately, there were two setscrews in the eccentric over the key, so we took out the key, set the eccentric in proper position and put in the other governor weight. After a few adjustments we had a nice-running engine and secured some good indicator diagrams.

H. R. ROCKWELL.

Alton, Ill.

Starting a Plant Shut Down for a Year

Rules to observe by an engineer on taking charge of a steam plant that has been shut down for one year are as follows:

Remove all boiler manhole and handhole plates, get into the boiler and look for signs of grooving and pitting; then see that all braces are sound, testing them by tapping with a hammer. The feed pipe should be examined to see that it is not filled with scale; also see that the discharge is not directly on the tubes or against the shell.

Remove all scale from the shell and tubes and before coming out of the boiler examine the blowoff pipe and know that it is sound and not filled with scale. The outside inspection consists of examining the brickwork, and repairing the setting if necessary; also put new sections in the grate if they are needed.

Examine and test the steam gage and safety valve and know that they are in good working order, also examine the the pipes leading to the water column and clean them out. The water column may or may not be set properly with respect to the boiler tubes. Set it so that when the water is 2 in. over the top row of tubes it will just begin to show in the glass. The feed pump should be newly packed and put in good condition. The feed water heater requires attention for it may be filled with scale; the pipe connecting with it may also be badly scaled.

When the engine is reached take off the cylinder head, and the steam-chest cover. If the cylinder is rusted it should be cleaned by the use of oil and the rust removed. The valves should be set properly and the seat put in good

condition, and all old packing on the piston rod and valve stems should be removed and new packing substituted. Examine the bearings of the engine before starting up and if they are cut or scored, scrape them until they present a smooth surface and adjust them until they are a proper fit.

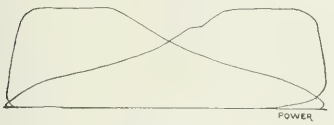
When everything has been put in running order, proceed to start up as under ordinary circumstances.

WILLIAM GOAL.

Gibsonburg, Ohio.

What Changes Are Necessary?

I would like to have readers of POWER tell me what they think of the accompanying diagrams and what change would be necessary to obtain the best results.



IS VALVE ADJUSTMENT NECESSARY?

The diagrams were taken from an Atlas four-valve engine.

J. D. GILMORE.

Hillsboro, Ill.

New Water Finder

Technical papers, when they make a news item of any miraculous scheme, invariably make the write-up so as to expose the "nigger in the wood pile." It is thus that these papers have built up for themselves a character of solid worth and they can be depended upon by the readers. But a recent number of a supposedly technical paper gave me an acute attack of "spinal come and git us." The caption of the article was "A New Water Finder," and when I read that "for finding water up to a depth of 200 ft. the instrument costs $150," I instinctively turned to the "Buyers' Guide" and "Index to Advertisements" to learn the price of stock, the bonus of "common" with the purchase of each share of "preferred," etc. The instrument can be readily used by unskilled persons, of course. The article said in part:

The principle on which the instrument works is the indicating of the presence of currents which flow between the earth and the atmosphere, and which, seeking the path of greatest conductivity, are always strongest in the vicinity of subterranean water courses, the waters of which are charged to a certain degree.

Would not that frost the pipes of your vertebral refrigeration system? If not, how is this?

The instrument indicates water courses flowing underground in a natural state, and not water pipes and sources that have sprung up to daylight. . . . . Observations should always be taken on a fine, calm, clear day between 8 and 12 in the morning and 2 and 5 in the afternoon, these being the hours of greatest activity of the vertical earth currents.

F. WEBSTER.

Philadelphia, Penn.

What Caused the Rod to Wear?

I have a spare 16x36-in. engine which has run daily from about 5 p.m. to 11 p.m. for the past five years. The piston rod got so I could not make the packing hold when the engine was loaded, and upon examination I found that the part of the rod in the cylinder when the engine was standing was smaller than the rest. I always stopped the engine with the crank-end crankpin over the center on the lower quarter as the engine ran over. This left about 12 in. of the rod in the cylinder.

The rod is round and in fine shape; the part in the cylinder is also round, but it has become smaller than the other part, and when the steam valve opens on the crank end the steam will blow out in a puff and the rest of the stroke will be all right.

The rod has had the best of care, it never was hot, and it was packed with four rings of soft packing which is never run tight. Why should the section of rod in the cylinder wear?

A. E. KERNICK.

Madison, Neb.

An Inexcusable Loss

Why is it that when the manufacturer has studiously designed his engine with the least possible clearance practicable, that the erecting man will so often carelessly put in long nipples between the cylinders and the drain cocks?

I know of two high-speed engines running at 275 r.p.m. which have a ¾-in. nipple 6 in. long, an ell, and a 12-in. nipple on each drain between the cylinder and the drain valves. In 10 years of service the loss on each of these engines, with coal at $3 or $3.50 per ton, will amount to quite a sum.

The above is an example where the nipples are unusually long. But ½-in. nipples from 6 to 10 in. long are common in the usual work of pipe-fitters, with a loss of steam due to condensation during the life of the engine. Where there are many auxiliary engines about a plant, the combined loss is a big item.

At a speed of 200 r.p.m., with 10 years the running life of an engine, both nipples will uselessly be filled with steam at full boiler pressure 2,102,400,000 times.

Therefore, the nipples should be made as short as practicable, or better still, drain cocks should be provided and screwed directly into the cylinder.

ROSCOE S. HELVIE.

Havana, Cuba.

Does Cold Air Cause Leaky Pipe Joints?

I have often heard that a draft of cold air in the vicinity of steam pipes will make the joints leak. The only explanation that I have ever heard is that the flanges contract; no mention of the bolts also contracting.

If cold air really makes pipe joints leak, I would like to have it explained. I have studied the matter somewhat and from experience I can arrive at but one conclusion—it is a fallacy.

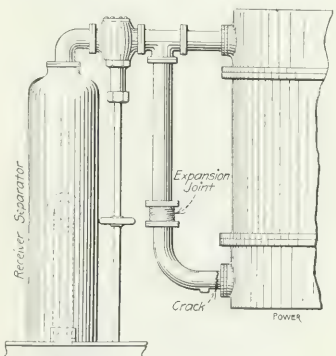
A good joint does not leak, cold air or not, but a joint may be leaky and the leak may not be visible on account of the small amount of escaping steam, in a very hot, dry atmosphere, when the steam is absorbed by the air before it is condensed. If cold air is admitted near the same joint, the steam is condensed before it is absorbed by the cold air.

WILFRID NORMAND.

New Bedford, Mass.

What Cracked the Ells?

The accompanying sketch shows the arrangement of the steam connection to the high-pressure cylinder of a 30, 60 and 90 by 66-in. triple-expansion engine. The ell at the bottom cracked all the way around with the exception of about



SHOWING WHERE THE ELL CRACKED

5 in., the break coming in the fillet to the flange.

This is the second ell breaking at the same place, but on different engines. Can some reader of POWER suggest a reason for these breaks? The cylinders are steam-jacketed.

H. R. BLESSING.

Philadelphia, Penn.

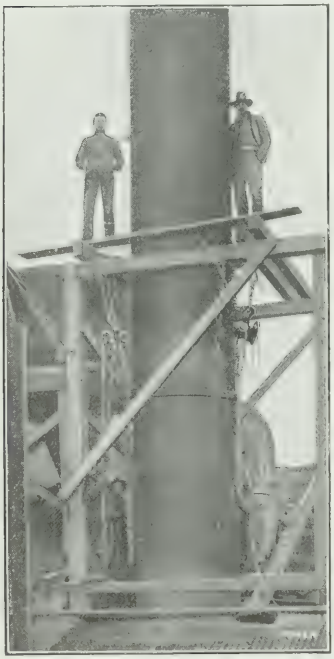
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Erecting Steel Stacks

I saw an article recently in POWER on raising steel stacks. The following plan is, I think, far superior to using a gin pole; in fact, a stack can be raised by this plan about as quickly as a gin pole can be raised.

Use is made of three or four sets of chain blocks and a band of as many pieces, which, after being clamped on the stack, will leave room enough between the ends to hook the chain blocks to the bolts. Each course of the stack is riveted on the longitudinal seam and



SHOWING STACK IN COURSE OF ERECTION

the band is clamped upon the first course, which is raised high enough to clear the second course. This course is then put in place, and riveted at the roundabout seam to the first. The bolts of the band are then slackened and the band is lowered to the under side of the roundabout seam where it is again clamped to the stack and the stack is raised to allow a third course to be riveted on at the bottom. This process is continued until the stack is completed.

At the proper places the guy bands are riveted and the guy wires anchored to steady the stack. As each course is put in place the guy wires will have to be slackened in order that the stack may be raised.

The accompanying figure shows the erection of a 60-in. by 75-ft. stack according to the plan just outlined.

H. A. TITCOMB.

Bellingham, Wash.

Belt Lacing

I have noticed that in all of the discussions on lacing belts the use of wire is regarded as rather unsatisfactory.

I know from long experience that if belts up to 8 or 9 in. wide are properly laced with small soft iron wire it is not possible to get as good results in any other way.

Holes should be punched with a small awl or the end of a file about ⅜ in. apart and not over $\frac{3}{16}$ in. from the edge. The wire may then be sewed in by hand, going twice through each hole and leaving it straight on the inside of the belt with the ends looped under one of the strands at the finish. Then the lacing should be put on the smallest pulley and pounded well into the leather. Failure to do this is what makes the wire break off.

There is no need to have a machine to do this work; it can be done just as well and more quickly with the belt hanging on the shaft. With a little practice, one can get a joint that cannot be noticed with the belt either running or idle, and the results will be fully equal to those secured with an endless belt.

The belts on woodworking machines are subject to very hard usage, but I have had 5-in. belts running at 5000 ft. per minute over 5-in. pulleys work for three months and the wire still show no signs of wear; in fact, all of the belts had to be taken up long before the wire gave out.

To put in new lacing, take a pair of snips and cut across the belt, then pull out the ends with pinchers, using one set of holes over again if the belt is to be shortened.

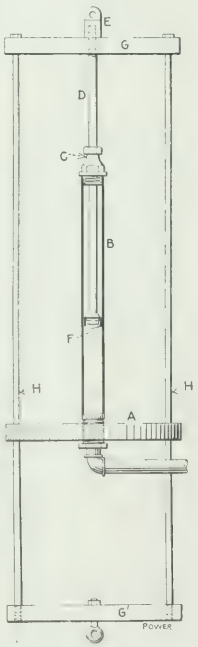
When rawhide lacing is used the holes pull out and an otherwise good belt becomes too short and worthless. This never happens with wire and a dollar's worth of it is sufficient in a big mill for a year.

V. L. BALLOU.

Shirley, Mass.

Home Made Damper Regulator

In POWER for Jan. 2, A. Seimes inquires for the design of a home-made damper regulator. The accompanying figure shows one that, while it will not control to a fraction of a pound, will nevertheless work fairly well.



SHOWING CONSTRUCTION OF REGULATOR

Referring to the figure, *A* is a cast-iron flange about 8 or 9 in. in diameter, drilled through the center and tapped for 1-in. pipe. Two $\frac{3}{16}$-in. holes are drilled on a line through the center and at a distance of 3½ in. from it for the ¼-in. guide rods, *H*. The cylinder *B* is of 1-in. brass pipe and about 12 in. long. One end is threaded and screwed into the flange *A* and the other end is

fitted with a small stuffing-box *C*. (A bonnet from an old valve will answer nicely.) The hole in the stuffing-box should be ⅜ in. in diameter for the piston rod *D*. This rod should be of brass, ⅜ in. in diameter and about 14 in. long. Both ends are threaded, and on one end is a leather disk *F* securely fastened and of a neat fit for the 1-in. pipe. The other end is screwed through a small piece of square iron *G* and then locked by screwing a piece of iron rod *E* on top. This piece in turn has a small hole drilled through it for connecting the damper wire.

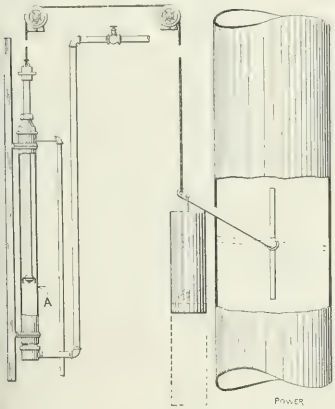
The top piece *G* also has two ⅝-in. holes drilled 7 in. apart for the ¼-in. guide rods, which are of sufficient length to allow a clearance of about 4 in. when the piston is all the way up. The bottoms of the rods are threaded and screwed into another square piece of iron *G'*, as shown. This iron has a ½-in. hole drilled through the center and an eye-bolt fitted in to carry sufficient weight to balance the boiler pressure.

Below the flange *A* there should be a 1x¼-in. bushing screwed into the 1-in. pipe and a small ¼-in. nipple and elbow for the steam connection. Two ½-in. holes should be drilled through the flange *A* before assembling so that it can be bolted to a bracket when complete.

GEORGE H. HANDLEY.

Newburgh, N. Y.

The accompanying figure illustrates the design of a simple and easily constructed damper regulator which I have used in my plant with good results.



EASILY CONSTRUCTED REGULATOR

The main cylinder *A* is a piece of 1-in. brass pipe 12 in. long with the cap of an old globe valve fitted onto one end. The other end is capped and a ⅜-in. pipe is screwed into this cap to form the connection with the boiler. A ¼-in. drain pipe is connected into the top end of the cylinder to get rid of any water that may collect on top of the piston. The piston rod is of ½-in. round iron. A leather-cup piston is held in place on the end of the rod by suitable washers and nuts.

The construction of the other parts of the regulator is self-explanatory.

MARTIN MCGERRY.

Holley, N. Y.

Breakage of Separator Gage Glasses

In the Jan. 9 issue, J. W. Dickson complains that he cannot get glasses to hold in separator gages and wonders if other engineers are having the same trouble.

In my plant there are two separators and we have found it almost impossible to get glasses to hold in them; the traps that discharge them blow glasses as fast as the separators. My reason for the trouble is the higher temperature to which the glass in a separator is subjected. The water stands in a boiler glass and I believe it cools to a much lower temperature than a separator glass for the separator is constantly getting a new supply of steam, thus having less time in which to cool. We have not broken a boiler glass in two years, but the same kind of glass will not hold in a separator.

EDGAR ALTMAN.

Cincinnati, Ohio.

Brick for Boiler Walls

In reply to the inquiry of Lewis L. Scheiderer as to hollow brick for boiler settings, I would say that I have been for two years in a plant having four 150-hp. return-tubular boilers. Two of them have been installed 14 years and the other two 8 years.

The settings of the first two have an outer wall 12 in. thick and an inner wall, 17 in. thick, with an air space between. The other two settings are solid.

The settings with the air space radiate less heat, "draw" better and stand extreme changes of temperature and frequent applications from the hose better than the solid settings, which are all cracked and warped.

If I were installing boilers, I would prefer hollow settings.

C. R. WARREN.

McArthur, Ohio.

In answer to Mr. Scheiderer's question in the Jan. 9 issue concerning hollow brick for boiler settings, I will say that in our plant two 300-hp. water-tube boilers in a battery are set as follows: On one side there is an 8-in. concrete wall cast in one piece against an 8-in. firebrick wall. Building paper was placed between the two walls to prevent a bond and to allow the brickwork to expand without cracking the concrete. On the other side there is an 8-in. concrete wall cast against a 4-in. hollow-tile partition wall which separates the concrete from an 8-in. firebrick wall.

The load carried is very regular and, as far as I have been able to tell, there is no difference in outside temperatures between the two walls. The hollow partition tile are laid so that there can be no air currents circulating in them. In both cases the firebrick only go to the second row of tubes from the bottom; above this point a solid 16-in. concrete wall is carried. The concrete does not rest on top of the firebrick. A space of 2 in. or more is left for expansion and to allow for variations in thickness of the firebrick when it comes to replacing them. The partition wall between the two boilers is of solid firebrick.

B. B. HOOD.

Winona, Mich.

License Laws

In the Jan. 9 issue, J. C. Hawkins states that the license laws are not what they should be because too little attention is given to the applicant's knowledge of safely operating engines and boilers. Mr. Hawkins chooses as an example the safe speed of flywheels and the safe operation and faults of different kinds of governors. He asks how many engineers are ever examined on these two subjects.

In Massachusetts there is seldom, if ever, an examination in which the applicant does not have to show his knowledge of the safe speed of flywheels. Not everyone is required to figure the bursting speed of a rim, but the question is asked in some way so that by his answer the examiner will know what his knowledge is of the speed of a given engine.

If an applicant in this state was examined and granted a license without answering questions on different types of governors, their operation, etc., he would think the examiner let him off easily. We are not only asked the principles of governors, but what effect different changes would have in the running of the engine, what the effect would be if the cause were a break in some part, and where to look for cause when the effect is given by the running of the engine.

Valve setting is about the only real work the applicant can do in the examiner's office, and when he is examined on this subject it is to find out how thoroughly he is acquainted with the practical duties of his vocation.

Mr. Hawkins also says that the examinations on boilers and piping should be more strict. I cannot see how they could be more so, in this state, and give a just examination. We are examined on the proper placing of piping to allow for expansion and drainage, and the proper placing of valves on all lines leading to and from the boiler.

Massachusetts bases its classification of licenses on the size and number of boilers in the plant, and pressure is also taken into consideration in the fireman's clause.

I do not agree with Mr. Hawkins when he states that old boilers should be under the care of the higher class engineers. An applicant is examined on the care and repair of old boilers and given a license only when the examiner thinks he is competent to handle them.

G. B. LONGSTREET.

Somerville, Mass.

Knocking in Air Compressor

In the last paragraph of the letter under the above title, by Frank Richards, published in the Jan. 30 issue, on page 165, the word "switched" referring to the crosshead should have been "swiveled."

Water Softeners

I read the letter by J. C. Hawkins in the Jan. 9 issue in which he asks for information in regard to water softeners.

Like other pieces of apparatus, a water softener has no brains, and it is necessary to put in certain chemicals, in certain proportions, at certain times. The quantity is determined by an analysis of the water. If the water softener is properly looked after, and properly designed, it should be able to soften the water so that there will be no scale in the boilers using the softened water.

Analyses of samples of water from points not far from Hyattsville, Md., show that the cost of softening the samples submitted was in the neighborhood of 1c. per 1000 gal. for the lime and soda ash required. Probably the average throughout the United States would be from 1c. to 2c. per 1000 gal. Of course, many hard well waters go considerably above this, but if it is necessary to use a hard water for boiler purposes, the cost of softening is more than repaid by the saving made in fuel, boiler repairs, etc.

There are several records of waters treated where their scale-forming material was so high that it cost over 15c. per 1000 gal. to soften them, yet the expenditure was more than repaid.

A water if only partly treated, say, by some so called purifying and heating processes, in which the carbonates might be removed and the sulphates left, might give rise to an extremely hard scale which would be difficult to remove, but by first analyzing a water and then using the proper proportions of lime and soda ash, the scale-forming sulphates are entirely removed and the carbonates reduced to such a point that they will not give rise to scale. When using such a water it is only necessary to occasionally shut down for washing out the very small amount of soft mud which comes from the treated water.

A careful investigation of water softening and an inspection of plants where first-class softeners are in operation will show that the boilers are entirely free from scale when the softener is properly operated, and that in a properly constructed machine very little time or attention is required to look after it.

F. S. DUNHAM,
WITH THE KENNICOTT CO.
Chicago, Ill.

Value of Compression

Referring to the editorial in the issue of Jan. 9 and the recent discussions on the subject of compression in steam-engine cylinders, I would say that in all steam engines, except straight-line air compressors and pumps which have sufficient resistance at the ends of their piston strokes, compression is a necessity, not only to secure quiet running but also to minimize repair bills. These are really the only valid excuses for its employment.

In filling clearance space by means of compression, the result can never be anything but net loss. We first generate power, by the transformation of heat, a portion of which is transmitted as the output of the engine, while the remainder is stored in the flywheel and other moving parts; we then exhaust the heat-carrying medium, with the exception of a portion, which is retained for cushioning, and proceed to employ the power stored in the flywheel to compress this low-tension steam into the clearance space, thus regenerating heat. The question is then: How can we reasonably expect to get back as much heat as we have expended in the process? The fact is, we cannot, as that would mean perpetual motion.

I do not doubt that heat is invariably less costly than its equivalent, in mechanical power. True, they are mutually convertible, but not without loss whichever way we attempt the conversion; therefore, in our efforts to produce power economically we would probably do better if we devoted more time to the study of how to get rid of that which has been spent. In other words, when the steam has once given up its useful energy, it should be exhausted as quickly and completely as is consistently possible.

Recognizing that compression is one of the necessary evils, I have always limited its production in a steam engine to such an amount as would just insure quiet running.

The work of various experimenters has conclusively demonstrated that not only is there no gain with compression, but that as it is increased, the losses due to it increase proportionately, which is just the result which I have observed in practice.

It is my opinion that the operating engineer has a very small chance to improve the economy of steam engines, his field being limited to the correction of derangements of valve setting which may occur in service, and that the only place where a material improvement is possible is on the builder's drawing-board, where the prime factors of economy—clearance and valve events—are laid down rather inflexibly.

CHARLES F. PRESCOTT.
Philadelphia, Penn.

Value of CO_2 Recorder

While I agree with Mr. Weaver in his letter in the issue of Jan. 9, that, in general, recording instruments are inductive as well as necessary to the economical operation of power plants and, while I believe in CO_2 recorders for test work, I differ with him in regard to their use in gaging the work done by the men in the fireroom. I base my statement on observations made in a plant containing 10 water-tube boilers of 4500 total horsepower.

When the CO_2 instruments were introduced an expert ran a test on one boiler and, if my memory serves me, 16 per cent. of CO_2 was obtained. Of course, the expert operated the damper and hauled it down as far as possible. As all of the boilers were on one steam main, the partial closing of the damper in one case did not materially affect the total output of steam. After the test was finished and due allowances made, a standard of 11.5 per cent. of CO_2 was established. Sampling bottles were put on all of the boilers and then commenced the work of living up to that 11.5 per cent.

The firemen were instructed to run with partly closed dampers; this they did and the result was that the steam pressure came down. Of course, the men then opened up on the dampers and when the samples were analyzed at the end of the first day there were all sorts of CO_2 averages ranging from 6 to 10 per cent. These conditions prevailed for a few days and then the men tumbled; they found that with the dampers closed and the blowers going full speed they could obtain a large percentage of CO_2. Consequently, they would fill the sampling bottles in a few minutes and then shut them off entirely; of course, this could only be done on the night watch when there were no bosses watching.

The result was that the night watch was praised and the day watch "got the dickens." After that the day watch would wait until noon and make their samples when the bosses went to lunch and there was a let-up on the steam.

On the whole, the office received satisfactory legitimate CO_2 samples. These came to average 12 and often times 14 per cent. This went on for a few weeks

when things began to happen; tubes commenced to drop and doors and furnaces burned out.

I then did a little experimenting on the oil-burning boilers, of which there are four in this plant. I found that by setting the damper so that smoke could be faintly seen coming from the stack, keeping the flame some 6 in. below the bottom tubes and by opening the sight shutters just far enough to look into the furnace I could obtain a percentage of CO_2 as high as 13.2. Also, after several trials, I found that by reducing the air space around the burners where they entered the furnace, better results were produced as I was then able to get an average of 14 per cent.

A. POHLMAN.

Brooklyn, N. Y.

Feed Water Regulators

In the Jan. 2 issue, Mr. Rockwell quotes the question, "What is the use of keeping the water level constant?" If the water level is not constant, how can a fireman regulate the fires to keep the steam pressure constant?

This in most plants is more or less essential, and, although I am not as familiar with the subject as others, I should think that if the water level varies much a plant would require a percentage of surplus boiler capacity equal to the percentage of variation of water level plus the percentage of load variation, in order to maintain uniform steam pressure.

W. R. SMITH.

Alton, Ill.

In further reference to the above subject, I wish to say that a regulator which does not permit of a constantly graduated feed to the boiler in proportion to the amount of evaporation is more detrimental to economical operation than hand feeding. There is considerable saving attached to the use of an arrangement which will perform the functions as stated above, while there is a proportionate loss where the controlling device affords an intermittent feed. This point was very forcibly brought out in a previous article on this subject, and it was not my purpose to oppose or in any way contradict any statements which have preceded mine.

When I referred to a good regulator in my letter in the Jan. 30 number, I had reference to one which does not necessitate the valve being slotted in order to allow enough water to pass the valve during the closed period to keep the temperature of the water from the heater as nearly uniform as possible. There is a regulator which does this automatically and I believe that if engineers will see all the regulators before purchasing they will be well rewarded for their trouble. I do not wish to go on record, however, as recommending any regulator which does not permit of a graduated feed.

C. L. JOHNSON.

Newark, N. J.

A Collegian's Come Back

In reading over some of the back numbers of POWER, I came across (in the number of Feb. 14, 1911, page 269) a filler relating the troubles of a certain college graduate in figuring out the increase of power required to double the output of a fan in his uncle's dry kiln. He made the mistake of assuming that to double the output of the fan he would have to cube the power input, thereby increasing the input from 5 to 125 hp. He then had to suffer the humiliation of being corrected by "Jim," who said that all they would need was another 5-hp. fan.

This article was evidently intended to satirize the lack of "horse sense" of the average college graduate. But is it not possible that, in his eagerness, the author overstepped himself?

According to the figuring credited to "Bill," if the original horsepower had been one, then the new horsepower required would be one ($1^3 = 1$). Evidently there is something wrong.

The theory the college graduate would naturally have in mind is not as stated in the article; he would argue that as the input varies as the cube of the output, to double the output would require an input of

$$5 \times 2^3 = 40 \text{ hp.}$$

As the article is evidently fictitious, the verdict of too much theory which the author intended to pronounce on the college graduate, finally reverts back on the author himself in the shape of incorrect theory.

After all, is it not fairer to assume that the liability to carelessness and that type of mistake depends on the man himself, and not on the fact that he is a college graduate?

H. E. RALPH.

Ithaca, N. Y.

Some Load

Answering H. T. Fryant's inquiry in the Jan. 9 issue as to the amount of loss in an 18x42-in. engine taking steam full stroke, I will say that I have made some approximate calculations which plainly show up the losses. The most economical cutoff for a simple Corliss engine, all things considered, is about one-quarter stroke.

According to Mariotte's law, relating to expansion of gases, the mean effective pressure would be 0.597 times the initial pressure. Allowing about 4 per cent. for clearance and compression and a card factor of 0.90, there is had for the final mean effective pressure, as shown by the indicator,

$$0.597 \times 0.96 \times 0.90 = 0.52$$

of the initial pressure, with one-quarter cutoff.

From Mr. Fryant's diagram there is found a mean effective pressure of about 0.71 of the initial pressure for four-quarters cutoff; hence, the ratio of work per pound of steam in each case is

$$\frac{0.52}{0.71} \times 4 = 2.93$$

that is, it takes about three times as much steam per foot-pound of useful work for the longer cutoff.

I say about, because the figure 0.52 for one-quarter cutoff is not strictly correct, as the ratio

$$\frac{M.e.p.}{Initial\ press.}$$

should be figured from absolute instead of atmospheric pressure as I have done because the scale of the indicator spring is not given.

B. S. NELSON.

Bayonne, N. J.

Mr. Fryant's indicator diagrams on page 64 of the Jan. 9 issue certainly indicate some load, and I imagine the owner pays some coal bills.

The information is very meager so that only a general idea of the saving in steam that can be effected by running the engine with proper cutoff can be stated. If the cutoff were 25 per cent., the amount of power would be about 60 per cent. of what is obtained with 100 per cent. cutoff, but at the same time the steam consumption would be decreased to about 25 per cent., depending on the clearance.

Thus, approximately the same power could be obtained with only 40 per cent. of the present steam consumption. This figure would vary, of course, depending on the load on the engine and the setting of the governor, but there is no doubt that a very large saving could be obtained.

W. L. DURAND.

Brooklyn, N. Y.

Using the Firm's Stationery

It is a most natural thing for the purchasing agent or the superintendent to "feel sore" at an engineer who goes over his head and orders some samples of oil, etc., to be tried out. A case in point is J. C. Hawkins' experience as related in the Jan. 16 issue; it was because of the fact that the engineer incurred the displeasure of the superintendent, that the oil was not ordered.

Would it not have been far better for the engineer to make a suggestion to either of the aforementioned to write officially for a sample instead of going

ahead himself and writing on the firm's stationery.

We must appreciate that a "live" concern—taking the oil and grease company as an example—is in business to "get the business," and when an engineer writes for samples, and later sends in a testimonial as to the worth of the material, the oil company will use this to get that firm's business. It is not a question with it whether the engineer took the sample merely for personal experiments; it is purely a case of "here is a prospective user who has found our grease good for his service, and now it is up to us to get his business." For this reason, the firm was followed up carefully with a request for the business and the engineer's recommendation of their product was sent with the request.

On the whole, everybody employed by a concern should not be allowed to use the firm's stationery as a matter of principle. There is a head to each department, and it would have to be a mighty good purchasing agent who could not take suggestions from the operating engineer or superintendent to get a sample of an article, the person recommending it believing that such requested material was for the benefit of the concern.

The concern itself ought to make a specialty of following up these requests, for, when an engineer takes the time to look up trade papers and advertisements to keep abreast of improvements, he shows, to my mind, an interest in his job.

NATHAN OWITZ.

New York City.

Sand for Hot Boxes

The discussion following the editorial on the use of sand in hot bearings has proved both interesting and instructive. It has served clearly to establish the facts that sand undoubtedly has been used to advantage in heated bearings and that the engineers of today are afraid to use it, though frequently using the finer grits like grindstone dust and Sapolio. However, no attempt has been made to analyze the action of sand to show the conditions under which it may be safely used and what conditions would render its use disastrous.

The instances noted where it has been used to advantage have all been in connection with marine work, mostly propeller-shaft bearings. These, of course, are large shafts running at low speed and are more than likely to have large clearance and some chucking motion from the direct action of the engine. If sand and oil are admitted to such a bearing, the sand will be instantly crushed to a powder and each grain will form for a moment a little oil stone, smoothing and polishing the shaft where it touches, and then be carried away by the oil. This process soon accomplishes the very satisfactory grinding of the shaft, when, of course, the heat abates.

The condition for successful use, then, is that each grain of sand shall be instantly crushed to powder as soon as it enters the bearing, when it forms a patch of grinding surface.

In a light, high-speed bearing, where the sand grains might not be crushed, some of them would likely get jammed in such a position as to present a cutting edge to the shaft. This would not only score the shaft, but would add small steel chips to further aggravate the trouble. Doubtless sand has its place in the care of large, loose bearings, but the engineer operating in the modern power plant does well to be distrustful of it.

G. M. WESLEY.

LaFayette, Ind.

On two occasions I have used sand for large bearings, and on many for small ones. On a large passenger steamer, trading between Glasgow and New York, the crankshaft was lined with new white metal. On the first trip after the overhaul, the two after-bearings gave a lot of trouble with heating, so we broke up an old grindstone and fed the dust into these bearings, running at low speed during the operation. The results were most satisfactory.

The other large job was on a 2000-hp. horizontal compound engine. One of the main bearings fired and the metal ran before the engine was stopped. The shaft was badly scored, owing to the weight coming on the narrow brass strips which held the white metal from flowing. We filed up the shaft and fitted in the spare set of bearings. The new bearings ran very hot and so we fed in grindstone dust and ran the engine at low speed. This was kept up all night, and the bearings were repeatedly washed out with the hose. At 7 a.m. we ran the engine at full speed and under full load, and it never gave any further trouble.

There is no necessity to use sand for every hot box, but there are cases where drastic remedies have to be adopted, and in such cases I would not hesitate to sand a bearing in order to bring it back to its normal condition.

W. DICK MACLEAN.

Paisley, Scotland.

Home Made Water Heater

Surely Hugh S. Russell must have considerable trouble with his home-made water heater as described in the Dec. 26 issue. If the water pressure is 40 lb., the steam pressure 45 lb., and there is an unlimited supply of steam furnished to the heater, it is certain that nothing but steam will be delivered at the water outlets. He says that it works satisfactorily at all times. This is hard to understand. Further, I would not imagine this heater to be a pleasant thing to have around for the steam entering directly into the cold water must make a very disagreeable noise.

In large, uptodate heaters the water-temperature regulating valve sometimes gets out of order, allowing the water to attain a temperature above the boiling point, corresponding to a steam pressure of 20 lb. When this happens, the water at the outlets will instantly flash into steam as soon as it reaches the open air. If the water reaches a higher temperature it will flash a little quicker, and this is what will probably happen to Mr. Russell's heater.

If a thermostatic valve were attached to the hot-water tank to automatically close off the steam supply when the water reached a temperature of, say, 200, or even 212, deg. F., the heater would be satisfactory.

Where I am employed there are water heaters delivering water 600 and 700 ft. away from the heaters and it is not satisfactory if the water attains a greater temperature than 212 deg.

JOHN THORN.

Toronto, Ont.

A Vacuum Puzzle

In the issue of Jan. 2, entitled "A Vacuum Puzzle," is an article by Leighton Johnson.

Mr. Johnson neglects to state how the high-speed engine was connected in service with the Corliss engine, and also the location of the vacuum gage. It might have been that the vacuum at the condenser was as high and possibly even higher than before the high-speed engine exhausted into it, and with the vacuum gage located at or near the small engine, or even at or near the large engine, the gage could show but 24 or 25 in. This, however, would not explain the rise in speed of the Corliss engine. It would seem, therefore, that the governor was not sensitive enough and could not control the speed of the engine.

It may, however, be that if the high-speed engine were connected to the same line shaft as the big engine, that the relative speeds would be such that the high-speed engine, having a slightly higher belt speed than the Corliss, would tend to speed up the line shafting. It is also quite possible that as some high-speed engines are large steam eaters, the excess steam used by this engine, carrying an excessive overload due to its higher speed and thus taking a larger proportion of the load than it was supposed to, is responsible for both the increased speed of the Corliss engine and the decreased vacuum at the condenser.

HENRY D. JACKSON.

Boston, Mass.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Refrigeration for Cold Storage

What is the refrigeration required for a cold-storage room 50 ft. long, 75 ft. wide and 10 ft. high, if 40,000 lb. of pork are daily placed in the room to be chilled from 95 to 35 deg. F. if the atmospheric temperature is 80 deg. F.?

F. M. H.

The determination of refrigeration required in a given case may be calculated by allowing first for the refrigeration necessary to keep the storage at a certain given temperature in consequence of the radiation through the walls. Second, for the refrigeration required to cool the articles from the temperature at which they enter the storage room down to its temperature. The rule to find the refrigeration to replace the cold lost by transmission through the walls is:

The quotient of the product of the difference of the outside temperature and the temperature required in the cold room and the number of square feet of surface of the ceiling, side walls and floors and the factor 3, for average construction and conditions, divided by 284,000.

The factor changes according to the character and construction of the walls, it being 5.5 B.t.u. for a brick wall 4½ in. thick to 2.2 for one 36 in. thick; from 6.2 B.t.u. for a stone wall 6 in. thick to 4.1 for one 36 in. thick. The surface of the walls is

$$2 \times 50 \times 10 + 2 \times 75 \times 10 = 2{,}500 \text{ sq.ft.}$$

The surface of the ceiling and floor is

$$2 \times 50 \times 75 = 7{,}500$$

$$10{,}000 \text{ sq.ft.}$$

Substituting figures for the rule, it would be expressed thus:

$$\frac{10{,}000 \times 3\,(80° - 35°)}{284{,}000} = 4.7 \textit{ tons}$$

The additional refrigeration required to chill the meat, assuming its specific heat to be 0.8, is expressed in the following formula:

$$\frac{40{,}000 \times (95° - 35°)}{355{,}000} = 6.76 \textit{ tons}$$

The total refrigeration required is

$$4.7 + 6.76 = 11.46 \textit{ tons}$$

Steam Engine Efficiency

What is the efficiency of a noncondensing engine which on a test took 26 lb. of steam per horsepower-hour, with an initial pressure of 115 lb., the steam containing 2 per cent. moisture and the temperature of the feed water being 210 deg. F.?

G. D. K.

The heat of evaporation of steam at 115 lb., or, say, 130 lb. absolute, is 872.3 B.t.u. Since the quality of the steam is 98 per cent. or only 0.98 is in the form of steam, it will take

$$872.3 \times 0.98 = 854.85 \textit{ B.t.u.}$$

to evaporate this quantity. The heat of the liquid at 130 lb. is 318.6 B.t.u. Therefore, the heat carried to the cylinder with each pound of vapor is

$$854.85 + 318.6 = 1173.45$$

the water at 32 deg. being considered as a base. The temperature of the feed water is 210 deg. F., but the heat of the exhaust is capable of heating the feed water to 212 deg.

$$212 - 32 = 180 \textit{ B.t.u.}$$

The heat supplied to the engine per pound of steam is therefore

$$1173.45 - 180 = 993.45 \textit{ B.t.u.}$$

and 26 lb. per hour will bring to the engine

$$26 \times 993.45 = 25{,}829.70 \textit{ B.t.u.}$$

A horsepower-hour is

$$33{,}000 \times 60 = 1{,}980{,}000 \textit{ ft.-lb.}$$

or

$$1{,}980{,}000 \div 778 = 2545 \textit{ B.t.u. per hour.}$$

To produce the equivalent of 2545 B.t.u. of work, 25,829.7 B.t.u. were used. The thermal efficiency is

$$\frac{\textit{B.t.u. of 1 hp.}}{\textit{B.t.u. used by engine}} = \frac{2545}{25{,}829.7} = 9.8\%$$

Factor of Safety

What is meant by the factor of safety?

G. R. R.

The factor of safety is the ratio of the strength of the material to the maximum load put on it; that is, if the factor of safety of a boiler is 5, the maximum load allowed is ⅕ the ultimate strength of the weakest part.

Soldering Cast Iron

Can cast iron be soldered?

L. G. M.

Yes; but it is a difficult job. The following method will give good results: Clean the parts well with emery or a file. Coat the parts to be joined with a soldering flux having a high proportion of zinc and bind them together tightly with iron wire. Then pack the edges of the joint with a thick paste of borax and water. Put the assembled pieces into a clear charcoal fire and as soon as they become dark cherry red, add finely divided solder and more borax. When the solder has run well through the joint, remove the piece from the fire and let the joint cool slowly. Do not clean off the surplus solder until the piece is quite cold.

Reversing an Engine

In bringing a large reversing engine to a standstill, is it good practice to reverse the engine with the throttle open to hasten the stop?

B. F. G.

This should not be done except in extreme cases. Shut the throttle and then throw over the reversing lever, utilizing the compression in the cylinder to facilitate the stopping.

Shunt and Compound Wound Generators in Parallel

What would happen if a compound- and a shunt-wound generator were run in parallel?

A. L.

Nothing very harmful; they would not divide the load proportionally.

Comparative Efficiency of Boilers

What factors should be considered in gaging the relative merits of water-tube and return-tubular boilers? With good water, what should be their comparative efficiency?

B. D. H.

Equally well proportioned to the work, set and operated, there should be no difference in their efficiency; one will evaporate as much water per pound of coal as the other under equally favorable conditions. The advantage of the water-tube boiler is the possibility of getting larger capacity into a single unit, and immunity from disastrous explosions.

Brake Horsepower

What is meant by brake horsepower?

N. P.

Brake horsepower is the power being delivered to the shaft. It differs somewhat from the power being produced in the cylinder because of the friction of the engine. It is the indicated horsepower less the frictional power of the engine itself.

French Boiler and Steam Receiver Accidents

The boiler catastrophe statistics of other countries are always instructive and salutary, but they are not altogether flattering to national vanity as may be seen in the following figures taken from the bulletin of the French labor office:

In 1909 there were reported 29 accidents occasioned by the use of steam, five of them causing only damage to inanimate objects or slight personal injuries. From the 24 others there resulted 15 deaths and 26 injured seriously enough to occasion 20 days' incapacity for work. There were 28 accidents and 13 killed and 41 injured in 1908.

If the number of accidents and the number of victims are compared with that of apparatus in use, the following averages are obtained for each 10,000 pieces of apparatus named for the last two years:

	Accidents		Killed		Injured	
	1909	1908	1909	1908	1909	1908
Steam boilers	1 9	1 9	1 0	1 3	2 1	0 8
Receivers	1 7	1 2	0 9	0 3	0 6	0 3

It will be noticed that the receiver accidents in 1909 were more numerous and disastrous than in 1908.

In the table following, during the period 1890 to 1909, it is shown that the frequency of accidents did not greatly vary until 1899; thence until 1904 there was a decrease, after which there was a further decrease from 1905 to 1909:

ACCIDENTS REPORTED TO EACH 10,000 PIECES OF APP RATUS

	Accidents	Killed	Injured
1890-94	3 0	1 8	1 6
1895-99	3 2	1 9	2 0
1900-04	2 3	1 5	2 2
1905-09	1 8	1 2	1 4

Air Reservoirs Explode

The air reservoirs in the Charlotte (N. C.) Electric Ry. Co.'s power plant exploded about 11 o'clock p.m. on Feb. 2 and nearly wrecked the building. No one was hurt. The reservoirs, located in the engine-room basement, were used for starting the gas engines.

The head of one of the tanks, about 9 ft. long and 5 ft. in diameter, was blown out and the cement floor above the basement was torn up for 10 or 15 ft.; the windows were blown out, and the water pipes on No. 1 engine were stripped.

Only a short time ago one of the boilers in the producer plant exploded and killed a fireman.

Power Plant Wrecked

On Jan. 30, the power plant of the Consolidated Ice & Power Co., at Valdosta, Ga., was wrecked. A car of coal being pushed up on the coal chute by a switch engine caught a guy wire, pulling down two smokestacks, two poles and completely demolishing the wire system. As a result, the city was left in darkness and the street-car service at a standstill. Nobody was hurt in the accident, but the plant presented a scene of wreckage, with one of the switchboards out of commission along with wires and poles.

Locomotive Boiler Bursts

By the bursting of the boiler of a freight engine on the Lehigh Valley R.R. near Somerville, N. J., on Feb. 4, the engine was thrown across the track of an approaching freight train and both engines were completely wrecked. The rear brakeman was killed and an engineer and a fireman injured. Four freight cars were derailed.

Engineers of "Diamond" Suspended

Following evidence given at the coroner's inquest and the investigation of the United States inspectors of steam vessels into the explosion of the boilers on the towboat "Diamond" in the Ohio River near Pittsburg, Dec. 3, Chief Engineer Charles Martin and Second Engineer Frank Price, of the boat's crew, were suspended for a period of six months. Five men lost their lives in the explosion. The body of Captain Edward Swaney was never found. According to Inspectors Isaac B. Williams and Charles G. Thomas, the engineers may get another suspension of their licenses when they make new applications.

Rhode Island Coal Co. in Receiver's Hands

John T. Burnett, of Southboro, Mass., was on Feb. 1 appointed receiver for the Rhode Island Coal Co. under bonds of $50,000 by Judge Dodge in the United States District Court, at the request of Henry M. Whitney, the president. Its coal mine is located at Portsmouth, R. I.

The company, which owes $704,337, is organized under the laws of Maine with a capital stock of $5,000,000. Shortly after it came onto the market the stock sold for $12 a share, but recently it fell below a dollar, and sold on the curb for 30 cents.

President Whitney is the principal creditor, having loaned $500,000 on notes. There is a mortgage on the property amounting to $120,000. Notes outstanding amount to $666,902.

OBITUARY

George H. Clark died at his residence in Brooklyn, N. Y., on Feb. 5. He was in his eighty-third year, and for over half a century had been the managing owner of the Salamander Grate Bar Co., New York City.

PERSONAL

J. G. Rossman, general manager of the Civic Light & Power Plant, at Winnipeg, Man., has resigned this $6000 position. It is said that Mr. Rossman objected to the interference of the Board of Control in his department.

Joseph F. Carney has been appointed chief engineer of the plant in the Hotel McAlpin, New York City, which, when completed, will be the largest hotel in the world. Mr. Carney is a past president of the National Association of Stationary Engineers and for years has been chief engineer at Sherry's.

E. P. Roberts, president of the Cleveland Engineering Society, has been appointed smoke inspector of that city by Mayor Baker. Mr. Roberts says that the department under his charge will not bring about abruptly the changes desired, and that educational work will be an important feature of the work. He favors the establishment of a smoke-observation station on the top of a skyscraper, and this plan may be worked out later in connection with the general reorganization scheme. The salary is $3600 a year.

Charles C. Moore, president of the Panama-Pacific Exposition of 1915, in his recent visit to New York City, said that everything points to a most successful exposition. Twenty states have already manifested their willingness to participate, and diplomats at Washington are deeply interested and are likely to recommend that their respective countries be represented. Mr. Moore is anxious that the opening of the exposition be simultaneous with that of the canal and also that every foreign land may participate and thus make the affair a really great universal exposition.

Charles H. Garlick, past president of the National Association of Stationary Engineers and prominently identified in industrial enterprises in western Pennsylvania, on Feb. 2 was appointed inspector of steam engines and steam boilers for Allegheny County by Governor John K. Tener. He succeeds J. J. Kelly, who has held the position about four years. Mr. Garlick was born in Ohio 50 years ago but has resided in Pittsburg nearly all his life. For more than a quarter of a century he has been actively engaged as a mechanical engineer, and for the last 15 years as consulting engineer for the Atlantic Refining Co. Previously he was employed as chief engineer of the Howard Plate Glass Co. and the Pittsburg Plate Glass Co. He is a member of the Engineers Society of Western Pennsylvania, a member of the Ohio Society of Electrical and Mechanical Engineers and past chief of the Universal Council of Craftsmen and Engineers.

POWER

Vol. 35 NEW YORK, FEBRUARY 20, 1912 No 8

RECENTLY one of our readers related the following story which points its own moral:

"The owners of a plant I visited a few weeks ago look upon their engineer as a necessary evil—*which they endured at the lowest possible cost to themselves.* This engineer is paid wages barely enough to keep him on the job, but not enough to satisfy him that he is receiving fair pay for what he knows and the amount of work he performs. Consequently, he cannot settle down and take the interest in his work that he should and would if he were getting slightly better wages and a little considerate attention.

"He has to order supplies—waste, oil, packing, etc.—weeks ahead, keep after the owners until he gets them, and then the material is always of the very cheapest grade.

"Once, this engineer requested to be supplied with a steam-engine indicator. He was flatly refused. No amount of argument would convince the owners that such a thing was at all necessary.

"Now, these same owners often wondered why a neighboring plant of about the same capacity and equipment can run with operating expenses 40 per cent. lower. I learned that the engineer of this other plant had been discharged by the first people two or three years ago—for incompetence, so they told me. Having the time to spare, I decided to visit the other plant. I would that the owners of the first plant had gone with me. They would have learned a lesson which would have been worth hundreds of dollars to them.

"I found the engineer, a young man in the early thirties, sitting in the engine room looking over his technical paper. He gladly showed me about. Everything about the plant was clean and neat. The engines were running quietly and the boiler settings and the piping seemed to be in the pink of condition. A neat steel locker stood in one corner and contained such supplies as packing and waste.

"A barrel of oil was delivered while I was present. The engineer tested a sample and the barrel was rejected as not up to previous grade. He explained that the policy of this plant was to get good oil, packing, etc., as they cut down repair work and expense.

"The engineer handed me a set of indicator diagrams that had been taken only a few days before; they showed that the engines were properly adjusted and in good operating condition.

"He said that he had only to explain to the owner the purpose of the indicator when one was gotten at once. Not only this, but the owner has become quite an indicator expert himself and can take a diagram, figure the horsepower and understand what the diagram tells.

"This engineer receives $5 per week more than the other. I could see long before I left how the people at this plant are able to operate it for so much less than it costs the other people. In the one plant they buy cheap supplies, and are buying all the time. In the other, they buy the best for their conditions and hence buy seldom. In one plant the engineer is always making repairs—his work is never done. In the other, the engineer has time in which to study and better fit himself to look out for his employer's interest."

Water Power Development in Ohio

By E. F. Baker

A series of five plants totaling 14,000 kw. in capacity will be erected on the Maumee River and its tributaries. The energy developed will be sold within a radius of 50 miles from Columbus.

When the present comprehensive plans of the Auglaize Power Co. have been fully developed, five hydro-electric plants will have been erected and for their power will draw on the waters of the Maumee River and its tributaries, which have their outlet in Lake Erie. These waters constitute the drainage for an area of more than 6000 square miles and this enormous power, which has heretofore gone to waste, will then be utilized for driving machinery in factories in the various municipalities all along the valley, and to the operation of numerous interurban electric roads which traverse this territory.

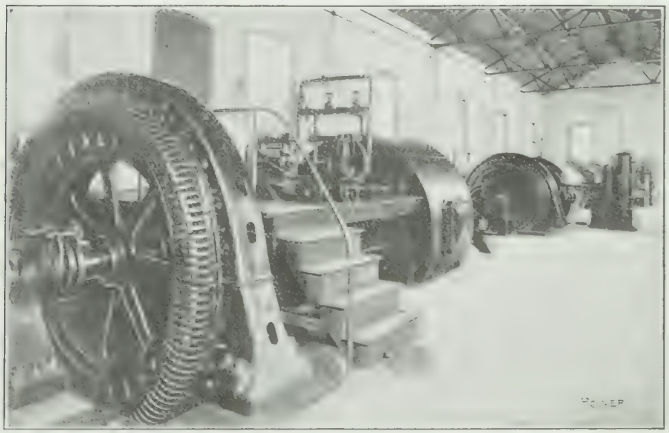


FIG. 1. GENERATING EQUIPMENT AT MAUMEE PLANT

The first of the series of hydro-electric plants has already been constructed at Maumee, Ohio, about 10 miles from Toledo, and is now in successful operation. The next plant was erected on the Auglaize River, near Defiance, and is still in the course of construction, while the others will be located at Oakwood, Melrose and Antwerp. Not only are the waters of the Maumee and Auglaize Rivers utilized but also the surplus waters of the Grand and Loramie reservoirs, near St. Mary's, Ohio, the former being the largest artificial body of water in the world, and the surplus waters of the Miami & Erie Canal.

A few years back, a company was formed and the old Detwiler water-power plant near Maumee, a one-wheel water unit with an auxiliary steam plant of approximately 800 hp., was installed and for some time operated an interurban belt-line railroad and other properties in that vicinity. The project was not wholly successful, however, and the plant was finally shut down. The Maumee Valley Electric Co. was then organized and secured this plant which became the nucleus of the first development and the site of the first hydro-electric plant. Some of the machinery originally installed was used in the new venture.

From the broad reaches of the Maumee River at Toledo, the Miami & Erie Canal ascends around the rapids above the city by a series of locks leading to a level section 23 miles in length and fed from the storage reservoir impounded by the New Grand Rapids dam built by the state a couple of years ago. The location of the Miami & Erie Canal, about 1800 ft. from the Maumee River, made a natural site for the hydro-electric plant which was ideally perfect, cutting down expense in a most obliging manner, as the Grand Rapids dam made a dam at the plant unnecessary.

The canal bed was dredged to a uniform depth of 7 ft., the entire distance between Grand Rapids and Toledo. The company also blasted out a rock bar which impeded the flow of water in the canal near Waterville, thus gaining a material increase in volume.

There is a drop of 621 ft. in the 1800 ft. between the canal and the Maumee River. The level from which the water is drawn for the plant is 18 miles long from the intake at Grand Rapids to Lock 45, which is a mile below the plant. This gives a reservoir of about 18 miles in length. A new forebay was built with the necessary headgates for handling the water from the canal. From the headgates the water passes through iron pipes 7½ in. in diameter directly into the wheels, their draft tubes discharging into the river.

The power house includes the new waterwheel structure, 110x30 ft., and the old combination plant building, 70x200 ft., containing the boilers and engines originally installed. The new building has concrete foundations set solidly upon bedrock, with walls of brick and steel trusses supporting the roof.

In this building were installed two 750- and one 450-kw. Allis-Chalmers three-phase, 60-cycle, 2300-volt gener-

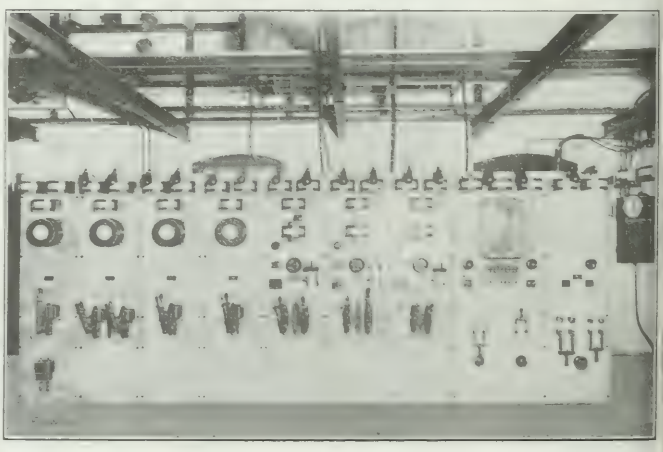


FIG. 2. SWITCHBOARD AT MAUMEE PLANT

ators. The 750-kw. machines are direct-connected to Allis-Chalmers horizontal hydraulic turbines of 1000 hp. capacity each. The 450-kw. machine is direct-connected to a Leffel wheel of 650 hp. capacity and also to a countershaft operated by a 600-hp. Hamilton Corliss tandem-compound engine. The engine

FIG. 3. AUGLAIZE RIVER IN FLOOD

and Leffel wheel can be operated singly or together at will. The exciters for the small machine are belt-driven while those for the two larger units are direct-connected to their own generators.

The operating platform is situated at one end of the power house and here are located one 500- and one 300-kw. 60-cycle General Electric rotaries which supply current for the Maumee Valley belt-line interurban railroad, 18 miles long, which passes in front and in close proximity to the plant. All the leads from the generators are carried through fiber conduits under the floor of the switchboard gallery which is part of the operating platform. These cables are carried up through the floor into type K three-pole General Electric oil switches.

The current is carried to the 2300-volt busbars located above and at the rear of the board from the oil switches. The feeders from the busbars pass through the same type of oil switches to the transformers for the rotaries and the high-tension distribution. The alternating-current operating voltage of the rotaries is 370. The outgoing high-tension lines carry 13,200 volts. There are two banks of these high-tension transformers and each bank is provided with disconnecting switches. The recording instruments were furnished by the Westinghouse Electric & Manufacturing Co., and all other instruments on the board by the Wagner Electric Manufacturing Co.

The operation of the Allis-Chalmers hydraulic turbines is controlled by the new type I oil governor. The Leffel wheel is controlled by an old type Lombard governor. The steam plant, installed as an auxiliary and to be used in case of urgent necessity, is equipped with four 200-hp. boilers.

At Defiance, Auglaize development No. 1, which is located about 3½ miles above the city on the Auglaize River, is nearing completion and will be in operation, it is expected, within a few months. The installation has not yet been made as the machinery is only partly finished. The power house is 230x35 ft. and 45 ft. to the roof trusses. Here four 1000-kv.-a. Allis-Chalmers, three-phase, 25-cycle generators will be installed and provision will be made for an extension of the plant to another unit of the same capacity as the first.

At this place it was necessary to erect a dam 600 ft. long with an 800-ft. retaining wall on the west side of the river. The dam will be 35 ft. high and the power house will be located at its eastern end. This dam will back up the water for about 15 miles, where the waters of the Grand and Loramie reservoirs will empty into the reservoir. This will assure plenty of water at the times of the year when the river is low. The dam itself is of hollow-concrete construction, which is considerably cheaper than the solid concrete and pronounced by experts just as safe. This is anchored into the blue limestone which forms the river bed by concrete walls 11 ft. deep and has a reinforcement of steel rods. Throughout the length of the dam vertical supports are placed every 15 ft., with an angle on the upstream side of 45 deg. On the angle there is placed the deck which is 2 ft. thick. The crest of the dam is 6 ft. wide and 2½ ft. thick.

Below the power plant now under construction will be installed an auxiliary steam plant to be used in case of trouble with the hydro-electric plant.

As previously stated, the Auglaize development No. 1 at Defiance has a capacity of 4000 kw., and the plant at Maumee, 2000 kw. The next plant to be built, that at Oakwood, will have a capacity of 2500 kw., the Melrose installation will have a capacity of 2500 kw. and the one at Antwerp 3000 kw. The cost of the plant at Defiance, including the transmission lines 5 miles above the city, is $125 per kw.

Pittsburg Smokeless

Because of the substitution of hydro-electric power for coal, a smokeless future is predicted for Pittsburg. There have been reports that Niagara Falls, under the international waterways treaty which goes into effect Mar. 1, would furnish the power, but coal is too cheap in Pittsburg for Niagara-generated electricity to compete with successfully.

Joseph R. Paull, of the Joseph R. Paull Investment Co., predicts, however, that the water of local rivers will provide plenty of power. It is planned, among other things, to dam the Clarion and Tionesta rivers for power uses. Three dams are to be built to form a reservoir or lake 52 miles long on the Clarion River. The plans which are now being considered by the water-supply commission at Harrisburg contemplate an expenditure of $10,000,000. It will be several years, however, before power can be supplied after work on the reservoirs is begun.

FIG. 4. EASTERN END OF DAM AT DEFIANCE

Firebrick Furnace Arches

By A. E. Dixon

Many failures of firebrick arches are due to poor workmanship in building them. Suggestions are given as to the proper mortar to use and how to lay the brick, together with calculations for determining the various dimensions.

Trouble with arches when exposed to intense heat is usually due more to the fact that few bricklayers are posted on the laying of firebrick, than to the firebrick itself. The inexperienced bricklayer seems to have the idea that his trowel is necessary on firebrick work, when in reality all that he needs is his "scutch" or hammer.

Fireclay mortar must be very thinly mixed. Occasionally an attempt to describe it in the specifications reads: "Mixed to the consistency of a thin gruel." Within limits, the thinner it is, the better. A thin batter that will flow readily is a better description. Pails are used to carry this mortar and the bricklayers should be supplied with tubs.

The brick should be dipped in the mortar in such a way that the surface to be exposed to the flame or heat and two-thirds of the surface in the wall do not receive any mortar. The back of the brick and the rear third of the wall surface only are covered with the mortar. The bricks must be hammered up tight to each other and the seams on the face of the wall should be very thin—too thin to admit a jack-knife blade; the fire-face of all seams must be slightly open. These open seams are necessary in order to permit the fire-face of the brick to expand slightly when heated.

Fireclay

The fireclay used for mortar should be the same clay as used in the brick. Raw or unburnt clay is frequently used, but the best mortar is made from a mixture ranging from 20 to 30 per cent. of raw clay and 70 to 80 per cent. from old firebrick ground for this purpose. The two kinds of clay are thoroughly mixed before they are wet. The mortar should be mixed with water in a tank or tub and allowed to stand at least 48 hours before it is used.

Boiler Furnaces

Taking a lesson from heating-furnace construction, it has frequently seemed to the writer that boiler furnaces could with advantage be constructed along similar lines, the face of the walls from the grate to the top of the fire, or a few inches more, being faced with either chrome or magnesite brick. These bricks are extremely refractory, and for boiler use the chrome brick would probably be the better. Chrome brick should be laid in a mortar of ground chrome ore and magnesite brick in magnesite cement; they should be laid in the same manner as firebrick. Both chrome and magnesite brick are extremely hard and cannot be cut or broken easily. An emery or carborundum wheel will grind them slowly, but it is nearly as hard on the wheel as it is on the brick.

Firebrick Arches

In building arches, centers are necessary. These should be made long enough to take 1½ arch rings, two or more being provided to get the length desired. The amount of centering required will depend upon whether the arch rings are bonded or keyed into each other. Straight rings generally give less trouble in construction and repair than keyed arches. The brick for an arch should be selected so that they will fit in without any cutting, though rubbing the tapered sides of

Fig. 1. Showing Straight and Shaped Bricks

two or three bricks may be necessary. Preferably arches should be designed as shown in Fig. 1. The skewbacks should be kept away from the face of the wall and when possible they should be supported entirely independently of the walls and buckstays provided to take the thrust of the arch; then the walls can be finished off so as to protect the lower part of the skewbacks, as shown at *A*. The bricklayer should be provided with a diagram showing the number of shape and straight brick required in each ring and their location, as is marked on a part of the arch in Fig. 1.

Firebrick arches generally have a rise of from 1½ to 2½ in. per foot of span. The flatter the arch, the greater the thrust upon the skewbacks and buckstays and the greater the pressure on the bricks near the spring of the arch. As firebrick are not adapted to carry great weights, particularly when exposed to high temperatures, an arch should be given as great a rise as possible, particularly if of any great length of span. Spans under 4 or 5 ft., however, can be made very flat. The thrust of an arch under a uniform load may be computed by the formula:

$$T = \frac{1.5\,p\,d^2}{h}$$

in which

T = Thrust in pounds per square foot of cross-section per foot of length of arch;
p = Load on arch in pounds per square foot;
d = Span of arch in feet, skewback to skewback;
h = Rise of arch in inches.

In the case of firebrick arches, the weight per cubic foot can be assumed as 130 lb.; this will be the load per square foot if the arch is 12 in. thick. The values of p for thicker or thinner arches are proportionate. The thrust per lineal foot T and the spacing of the buckstays should be such that the tie-rods are not stressed higher than 9000 to 10,000 lb.

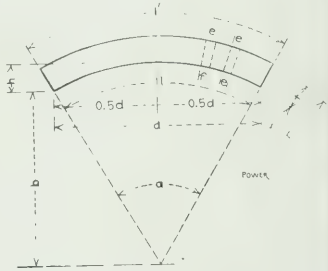


Fig. 2. Diagram Showing Meaning of Letters Used in the Formulas

per square inch. Skewback supports are desirable to carry the arch-thrust between the buckstays. Heavy angle or channel irons are frequently employed. These are subjected to bending stresses and should be worked at very low fiber stresses in order to avoid the racking of the brickwork which would be occasioned if they deflected or sprung very much under the loads placed upon them.

Rise of Arch upon Thrust

In order to illustrate the effect of the rise of an arch upon the thrust, the thrust of an arch 12 in. thick with a span of 12 ft. 6 in., has been computed for four different rises. This span is approximately the width of the firebox under a 600-hp. water-tube boiler.

Rise per Foot, Inches	Thrust, Pounds per Linear Foot
1 0	2,420
1 5	1,630
2 0	1,220
2 5	975

The total rise for these four cases would be 12.5, 18.75, 25.0 and 31.25 in.,

respectively, and while the first is so flat that it gives a pressure on the skewbacks of 16.8 lb. (2420 ÷ 144) per square inch, it is not unreasonably high. The other rises would be too high for a coking arch under the tubes of a water-tube boiler, but they would be all right in a dutch oven. It is not desirable to run the pressure on firebrick much over 25 lb. per square inch or 3600 lb. per square foot.

Method to Determine Number of Brick

Knowing the rise of the arch and the span, the following method can be used to determine the number of shape and straight brick required for each ring. The lettering in the formulas and on Fig. 2 is the same. The radius of the arch is found as follows:

$$r = \frac{(0.5\,d)^2 + h^2}{2\,h} \qquad (1)$$

d, h and r being taken in the same units, either feet and decimals of a foot, or inches.

The sine of half the angle of which d is the chord when the radius equals r is found from

$$Sine\ \frac{a}{2} = \frac{0.5\,d}{r} \qquad (2)$$

Reference to a table of the natural trigonometrical functions will give half the angle a, and this multiplied by 2 will give the angle a. If a table of chords is available, the angle can be found by dividing the chord d by the radius r. The accompanying table gives the angles of which the chord is the length of span, corresponding to various rises per foot of span.

Inches Rise per One Foot of Span	Arc, Degrees	Inches Rise per One Foot of Span	Arc, Degrees
$\frac{1}{8}$	37° 0′	1	63° 15′
$\frac{1}{4}$	39° 0′	$1\frac{1}{8}$	65° 0′
$\frac{3}{8}$	41° 0′	$1\frac{1}{4}$	66° 0′
$\frac{1}{2}$	42° 30′	2.0	67° 15′
$\frac{5}{8}$	44° 0′	$2\frac{1}{16}$	68° 15′
$\frac{3}{4}$	45° 30′	$2\frac{1}{8}$	69° 15′
$\frac{7}{8}$	47° 0′	$2\frac{3}{16}$	70° 15′
1.0	48° 30′	$2\frac{1}{4}$	71° 30′
$1\frac{1}{16}$	50° 0′	$2\frac{5}{16}$	72° 30′
$1\frac{1}{8}$	51° 30′	$2\frac{3}{8}$	73° 30′
$1\frac{3}{16}$	52° 15′	$2\frac{7}{16}$	74° 15′
$1\frac{1}{4}$	54° 15′	$2\frac{1}{2}$	75° 15′
$1\frac{5}{16}$	55° 30′	$2\frac{9}{16}$	76° 15′
$1\frac{3}{8}$	56° 45′	$2\frac{5}{8}$	77° 15′
$1\frac{7}{16}$	58° 0′	$2\frac{11}{16}$	78° 15′
$1\frac{1}{2}$	59° 15′	$2\frac{3}{4}$	79° 15′
$1\frac{9}{16}$	60° 30′	$2\frac{13}{16}$	80° 15′
$1\frac{5}{8}$	61° 30′	$2\frac{7}{8}$	81° 0′
$1\frac{11}{16}$	62° 30′	$2\frac{15}{16}$	82° 0′

The lengths of the arcs measured along the upper and lower surfaces of the arch are found by the same formula, the radius in one case being that of the under side of the arch and in the other that of the upper surface of the arch. The formula given here is for the under surface.

$$l = \frac{6.283\,r \times a\ (in\ degrees)}{360} \qquad (3)$$

If r is in feet, l will be in feet. For convenience in figuring, a should be in degrees and decimals of a degree.

The difference in the lengths of the inner and outer surfaces of the arch is the amount which must be taken up by the taper of the total number of shape brick required; denote this difference by k. Then

$$l' - l = k \qquad (4)$$

and

$$e - f = g \qquad (5)$$

In which:

e = Thickness of large end of tapered brick.

f = Thickness of thin end of tapered brick.

g = Difference in thickness between the two ends of the brick.

Furthermore

$$\frac{k}{g} = n \qquad (6)$$

the number of shape brick required for the arch. And

$$\frac{l}{e} = n'' \qquad (7)$$

the total number of brick required for the arch.

$$n - n' = n'' \qquad (8)$$

are the number of straight brick required for the arch.

The shape brick should be arranged to form a symmetrical curve by separating them from each other by straight brick; that is, if an equal number of shape and straight brick are required, they will be placed alternately, but in flat arches two or three straight brick may have to be placed between each shape brick. That shape brick should be selected which will give the smallest number of straight brick, as it is not desirable to separate the shape brick with more than two straight ones.

Troubles with White-Metal Bearings

By E. F. Butler and J. N. Kilby

A large steel works, having experienced trouble from bearings run with anti-friction metal, called in the writers to investigate and rectify the trouble. The principal faults were short life, spreading or pounding out, breaking up in the shell and cutting and scoring of the shafts.

The practice of the firm was to buy its bearing metals on a given chemical analysis. Therefore, a number of bearings that had failed during service were analyzed to see if they came up to specifications, and various results were found in bearings from the same delivery. To push the matter still further, samples were taken from one bearing and found to differ from end to end. As a typical example, a bearing which should have contained 2 per cent. antimony had only 0.5 per cent.; the tin also varied.

We resolved to effect some improvement in melting and running up, and built a furnace for that purpose. This consists of four cast-iron plates clamped together and lined with a good quality of firebrick. Across the bottom, bars are placed, and near the top of the back wall a short flue connects with a stack which should not be much less than 20 ft. long and 6 in. diameter. The cover is formed by several firebrick laid side by side and clamped together, and the metal is melted in a plumbago crucible with a lid of the same material. For ordinary sizes the inside of the furnace can be three times the diameter of the crucible in width and twice its height. The furnace should be started by a coal fire and half filled with 2-in. hard coke free from dust. The cover is placed on and when the coke has taken fire thoroughly, all traces of the coal should be removed. Next break up the white metal and place it in the crucible with alternate layers of charcoal and cover the top with more charcoal. Place the lid on and put in the furnace, ram the coke tightly and put the cover on the furnace. Forty pounds were melted easily in as many minutes, although air under pressure between the bars will hasten the action. It may be mentioned that this is the stage at which more bearings are spoiled than at any other.

Even in important concerns, the running of bearings is often left entirely to the workman. Metal from the stores is used with trimmings from previous casts, borings from the lathe often mixed with brass and other turnings are all melted in a dirty ladle at the first fire that comes handy. The metals which melt first will vaporize and a loss of metal will result. This is particularly so in the case of tin, which has a very low melting point, and as it has high lubricating qualities and, moreover, is comparatively expensive, it is worth while going to some trouble to retain it unaltered.

Another disadvantage of melting in an open ladle is the forming of a scum (oxide) which is sufficient in the finished bearing to score the shaft. By melting in a covered crucible, as described, all these disadvantages are done away with, the result being that the finished bearing gives the same analysis as the unused metal.

As regards the actual running, little need be said. Warm the shell of the bearing previously so that it can barely be touched. The larger the shell the more important this is. When a core is used have it as smooth as possible. By holding it over a smoky flame until it becomes covered with soot it will leave a smoother surface and not stick to the metal. Pour the metal as slowly as possible; this lessens the chance of blowholes and gives a solid bearing.

By these methods most of the difficulties were overcome. In some places, particularly in the rolling mills, the life of the bearings was not as long as could be desired, but an improvement was effected by replacing some of the softer metals by an addition of aluminum.

Confession of an Engineer

By R. O. Warren

Using information published in an advertisement, the engineer is enabled to show Manager Wood that he is onto his job.

He also puts one over on the smoke inspector by challenging his reports and proving that they were false by means of a chart taken from an automatic smoke recorder.

My work and Manager Wood gave me no trouble for several weeks after putting the strainers on the pump-suction pipes. In the meantime cold weather had come, the boilers were necessarily fired harder, and occasionally the fireman got careless and there was some smoke.

Violating the Smoke Ordinance

Wood had cautioned me to watch the firemen more closely and to try and pacify the smoke inspector, who, having complained several times, had at last forced the company to pay a fine for violating the smoke ordinance. We had talked the matter over and, although I admitted that the firemen occasionally made some smoke, I did not believe that conditions were as bad as had been claimed by the inspector.

"Well, how are you going to prove it?" was the way Wood came back at me, and I had to admit that I could not.

"Since these complaints began about excessive smoke, I have done a little smoke inspecting myself," said Wood, "but the smoke issuing from our stack is not enough to warrant a fine. I am inclined to believe that the inspector of this district is attempting to hold us up and that his interest in the smoke problem is not based solely on his desire to keep the atmosphere clear and clean."

"Smoke has been made for a good many years," said I, "and we are not the first to be troubled by this nuisance. There have been smokeless furnaces built in which supposedly perfect combustion took place, but the smoke problem is with us just the same. Someone who has taken the trouble to find out claims that nearly 2500 patents have been issued during the past 20 years on smokeless furnaces, and yet with all this display of genius smoking chimneys are by no means abolished."

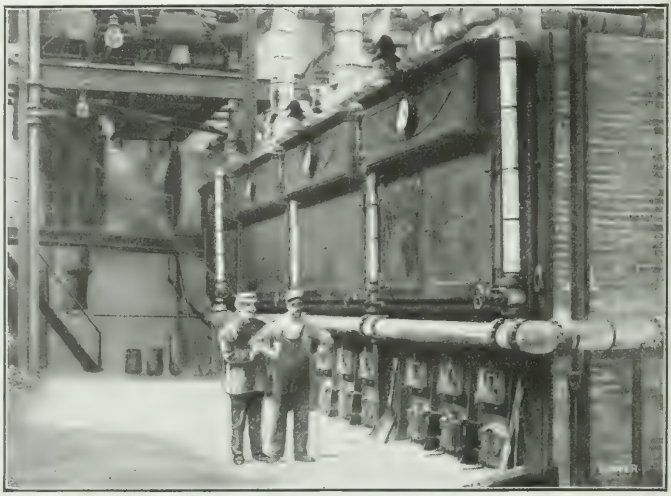
"Well, you don't mean to say that these patent furnaces are of no account, do you?"

"By no means," I hastened to reply. "Many of them are exceptionally meritorious and are built with but few faults, if such a thing can be said of any furnace, but no one of them seems to cure everything, like a patent medicine, and they never will."

"Why not?" asked Wood. "I have noticed that when a man knows what he wants, he usually gets it. I don't see why a smokeless furnace cannot be built just as well as other perfected devices."

Carelessness and Ignorance

"There are two elements which will always be found in the average boiler room, carelessness and ignorance, and they are the two greatest causes for smoking chimneys. Ignorant firemen—and by that term I mean men who do not understand the principles of combustion, how much air to supply to the furnace, and how to handle their fires—are usually the result of failure to properly instruct them in their duties."



I Told the Chief Fireman that the New Smoke-recording Device Would Help Us Get One Over on the Smoke Inspector

"Then that disposes of one of the objectionable elements which work against smokeless combustion," said Wood, as he seated himself in a more comfortable position.

"Yes, but there is the element of carelessness, and this is a mighty hard thing to eliminate. It is human nature and that is difficult to govern. The one way to decrease the carelessness of firemen is to make them understand that their work must come up to a certain standard; that there is a means of showing when and where they are careless and that their work is constantly under supervision.

"If a man is habitually careless, then there is nothing to do but discharge him. Of course," I added, glad to get a come-back at Wood, "you can't expect to have the highest type of experienced firemen, men who understand combustion in all its phases, for $1.65 per day."

"No, I don't expect anything out of reason for that money, but I do expect that the chief engineer will be on the job and will get the best service out of the men in the fireroom." With this shot, Wood looked at his watch, closed the case with a snap and disappeared through the engine-room door toward his office.

Warren Gets an Idea

I was somewhat dazed for a few moments after Wood's retirement. Here was a chance to do something to regain the ground I had lost through neglecting my opportunities and do things that would count. I knew that our slight smoke violation did not warrant a fine, but I could not prove it. And I said to myself: "How can I get one over on the smoke inspector, cut in ahead of Wood and perhaps secure an increase in wages for the fireman?"

As I sat thinking over the matter, unable to formulate any feasible plan for checking the inspector's report, the morning mail, containing a copy of Power, was brought in by the office boy. In looking over the advertising pages, I saw this headline in an advertisement: "Watch Your Stack and Check Your Fireman!"

That advertisement was inserted by a company making a smoke-recording device, and it claimed that one could tell at a glance how much or how little a

chimney smoked and that a constant record was made as to just how dense was the smoke issuing from the chimney.

"Just the thing!" I exclaimed as I finished reading the advertisement. I wrote for a catalog, which came in due time. Then I familiarized myself with its contents and came to the conclusion that the device was just what I needed, as it would make the firemen more attentive to their work. It would also show them where and when they were making smoke, how much was being made, when it happened and who was responsible.

Putting It Up to Wood

When I had the details of the device well in hand, I sent word for Wood to come down to the engine room and greeted him with, "I've got a stunt to pull off on that smoke inspector that will make him dizzy if you are game enough for the price. It's a smoke-recording device and, as far as I can judge from what the catalog says, it will save its original cost in a very short time."

"I don't see that a smoke recorder will save us any money," said Wood. "If the firemen do their work properly after being carefully instructed, there should be no fine for smoke-ordinance violation."

"Well, that isn't the only way to save money. It occurs to me that you came in here once upon a time and delivered quite a lecture on the money that was wasted through careless firemen. This device will make the men more careful as it records the amount of smoke going up the chimney. Smoke is a sure sign of incomplete combustion; I believe I heard you make this remark some months ago."

"What will this machine cost?" asked Wood, with a slight grin.

"About a couple of hundred, I suppose."

"I'll think it over. There may be something in what you say."

The Smoke Recorder Arrives

I heard no more about the matter until the machine arrived. It was set up and continuous charts were produced each day and filed for future reference. The firemen took kindly to the idea and a friendly rivalry sprang up as to who would produce the clearest chart. In a few weeks the smoke issuing from the stack was so much reduced that Wood said it sent a chill up and down his spine whenever he returned to the plant after being downtown as the smokeless chimney gave the impression that the plant was shut down.

The smoke inspector, however, was still on the job. The old complaints came in at intervals and, finally, a stiff protest and warning came from the chief inspector.

"Now is the time for you to make good with your smoke record," announced Wood the next morning after receiving the notice. "I have objected to the reports of the inspector and have offered to prove that they are false. Get those charts and we will go down to the chief's office and have this smoke business settled so far as we are concerned."

The Inspector Wilts

We proceeded to the chief inspector's office, to which the local inspector had been summoned. After the greetings of the day, the chief said: "Mr. Sawum, the inspector for your district, reports that on Dec. 17 smoke issued from your stack for a matter of 30 minutes between 12 and 12:30 noon in excessive quantities, and on Dec. 21 a similar violation occurred for 20 minutes, or from 2:20 to 2:40 p.m."

As each case was cited I laid aside the chart taken on that date and was gratified to observe that Inspector Sawum looked considerably disconcerted at the sight of them.

Something like a dozen dates when smoke violation occurred were read off and then the chief inspector finished by asking what excuse we had to offer.

"None at all," I answered; "there is none. If there is any explanation needed, it looks to me as if it were to come from your side of the house. For instance, on Dec. 17, between 12 and 12:30, there was no smoke issuing from the stack of our plant," and I produced the chart for that date, which showed that a very thin film of smoke had issued from the stack but a short portion of the 30 minutes stated by the inspector. The chart for Dec. 21 showed but a trace of smoke for the 20 minutes the inspector had reported the chimney to have been in a smoky condition.

In every other instance the charts showed that the inspector had faked his report. After the operation of the machine had been explained to the chief inspector, he halted the proceedings and promised to further examine the inspector's reports.

I think he did, for nothing more was ever heard of the matter and a new smoke inspector was detailed to our district a short time afterward.

Wood's severe lessons deeply impressed me and with the smoke recorder I was enabled to save the company from an unjust fine, show up the smoke inspector, and, best of all, find that the coal consumption had been greatly reduced since the device had been in operation. Wood felt so good over the showing that it was an easy matter for me to get an increase for the firemen.

Norway's great water-power advantages are the means whereby its increasing electrochemical industries will be conducted on a scale impossible in any other European country.

Would Lease Alaskan Coal Lands

In his annual report, recently made public, Secretary of the Interior Fisher recommends "a liberal but carefully guarded leasing law for the development of its mineral resources, and especially of Alaska's coal lands. Its greatest resources are her minerals, and in the development of these the precious metals still hold the predominant place. Careful consideration of the provisions of an appropriate leasing law for the coal lands of Alaska is being continued through the Director of the Bureau of Mines, with a view to suggesting such changes in or substitutes for bills on this subject, which are now pending in Congress, as may be desirable."

The Secretary urges also the construction by the government of a central trunk-line railroad from tidewater to the Tanana and Yukon; the reservation of a sufficient amount of the coal lands to provide for the future needs of the navy, this coal to be mined by the government.

"The whole subject of water-power development and control should, in my judgment, receive the immediate consideration of Congress," says the Secretary, "and constructive legislation should be adopted without further delay. I believe the Federal government has adequate constitutional power to control water-power development, both in navigable streams and upon the public domain, and to exact compensation and to impose proper conditions in either case. It is apparent that the Federal government can act more effectively than the states in many cases. No correct or permanent solution of the water-power question can be reached until the interests of the state and of the nation have been reconciled."

Long Acre Co. to Use Diesel Engines

The Long Acre Electric Light & Power Co., of New York City, expects to have its second power plant in operation within five months. The Diesel internal-combustion engine is the type of prime mover to be used, and the first one to be installed will be of 3600 hp. capacity.

It is the intention of the company to install power plants in several parts of the city rather than one central plant with substations.

The Long Acre Electric Light & Power Co. expects to become an active factor in the lighting field on Manhattan Island and in the Bronx within a few months. The Public Service Commission has authorized a bond issue of $50,000,000, of which $4,000,000 has been approved for sale. Within a year the company plans to have in operation five or six plants with an aggregate horsepower of between 25,000 and 30,000.

The Sturtevant Steam Turbine

When we last described the Sturtevant steam turbine it had just made its appearance upon the market. Experience and use have led to the usual adaptations and development, and it will be interesting to review it in its latest form.

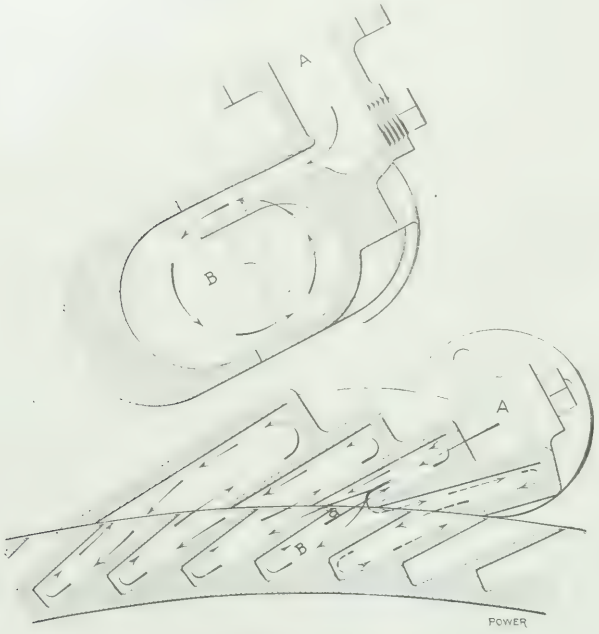


FIG. 1. SHOWING COURSE OF STEAM

This turbine, it will be remembered, is of the Riedler-Stumpf type, where a single wheel, with but one row of buckets, is made to serve for several velocity stages by returning the steam upon the wheel by means of reversing chambers, as shown in Fig. 1, the relation of which to the actual turbine will be made apparent by an inspection of Fig. 2. The steam enters through a nozzle which is designed to expand it to the exhaust pressure. With the velocity acquired by this expansion, it enters the bucket *B*, compelling by its impact the rotation of the wheel of which the bucket is a part, and leaving the far side of the moving bucket with its velocity reduced in proportion to the difference in the velocity of the jet and the wheel.

Suppose the velocity of the jet as it leaves the nozzle to be 2000 ft. per second, and that of the bucket to be 200. Since the bucket is running away from the steam at a speed of 200 ft. per second, the steam will overtake it and pass through it with a velocity, relative to the bucket, of 2000 — 200 = 1800 ft. per second.

Neglecting the effect of friction, it will leave the bucket in the reverse direction, with a velocity of 1800 ft. per second relatively to the bucket. But since it is being carried forward at the rate of 200 ft., its movement relatively to the stationary bucket, which it is now entering, is only 1800 — 200 = 1600 ft. per second. With this velocity it passes through the reversing bucket and is turned around to impinge again upon the wheel.

The energy stored in a moving body is proportional to the square of its velocity. To get all the energy out, the body must be brought completely to rest, but if the velocity is reduced to one-half, three-quarters of the energy will have been extracted. The relations of the velocities and energies in the abstract case which is being considered would be as follows:

	Velocity, Ft. per Sec	Energy per Pound of Steam	Energy Abstracted, Ft.-Lb.
First impact	2000	62,189	22,388
Second impact	1600	39,801	17,413
Third impact	1200	22,388	12,438
Fourth impact	800	9,950	7,463
Fifth impact	400	2,487	2,487
Discharge from fifth bucket	0	0	

Of course, in the actual turbine the steam cannot be brought absolutely to rest, and the velocity is reduced by other causes than abstraction by the wheel. The energy abstracted by the last impact is relatively unimportant (only about one-tenth of that by the first in the above table). The number of reversals employed will be determined by the initial velocity of the steam, which in turn is dependent upon the initial and exhaust pressures and upon the bucket's velocity, fewer reversals being required for the faster running turbine.

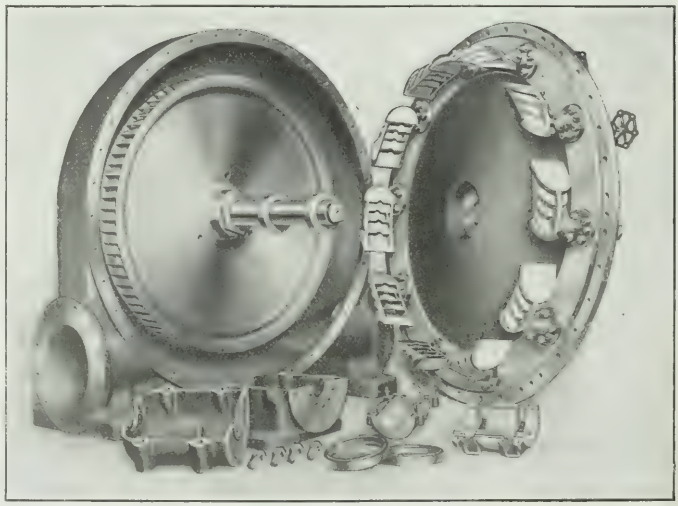


FIG. 2. INTERIOR OF STURTEVANT TURBINE

In explaining a turbine of this type a sketch, like Fig. 1, is usually made with the edges of the bucket and reversing chamber drawn line and line. This is, however, only a momentary or instantaneous condition. The greater part of the time the edge *a* of the first admission chamber will be opposite some part of the bucket entrance, so that a portion of the steam could blow back, as indicated by the dotted arrows, generating pressure and inducing leakage into the exhaust casing if its motion is stopped by making the nozzle block solid at this point. Some builders meet this condition by canting the edges of the stationary reversing bucket so that the discharge end leads to the center of the next wheel bucket.

One feature of the new Sturtevant turbine is a supplemental chamber back of the nozzle chamber, so that any steam

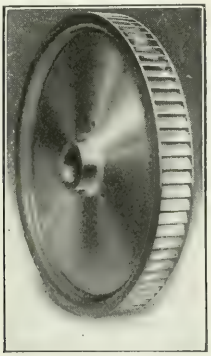


FIG. 4. THE ROTOR

which is diverted in this way will be reversed and thrown back into the wheel. This supplemental chamber is that shown at the right in Fig. 3, the rectangular space at the bottom of the next chamber being the outlet or mouth of the nozzle. Its use is said to have added considerably to the efficiency, especially at the lower speeds or higher steam pressures.

The nozzle blocks, of Tobin bronze, are cast in the form shown in Fig. 3, and are bolted to an annular chamber, forming an integral part of the steam head, as shown in Fig. 2.

This annular chamber, a section of which is visible in Fig. 5 and the exterior in Fig. 6, is the only portion of the turbine to which live steam is admitted. It has no openings except those to the nozzles, which are controlled by valves, as shown in the two views just referred to, and no joints except that of the entering steam flange; the flanges of the nozzles are made up metal to metal and provided with dowels, so that the nozzle will be accurately replaced in case it is necessary to remove it. The semicircular gaps in the partition separating the chambers of the nozzles serve no useful purpose, but are incidental to the machining process, affording room for the arbor of the milling cutter.

The interior surfaces of these chambers and partitions are highly polished to reduce frictional losses, and the cross-section of the chamber is progressively increased to take care of the same volume of steam with the diminished velocity.

The rotor, Fig. 4, is a solid forging of openhearth steel, made to the following specifications:

Phosphorus, not over	0.04 per cent.
Sulphur, not over	0.04 per cent.
Manganese	0.40 to 0.50 per cent.
Carbon	0.20 to 0.25 per cent.
Tensile strength	65,000 lb.
Elastic limit	35,000 lb.
Elongation in 2 in.	25 to 35 per cent.

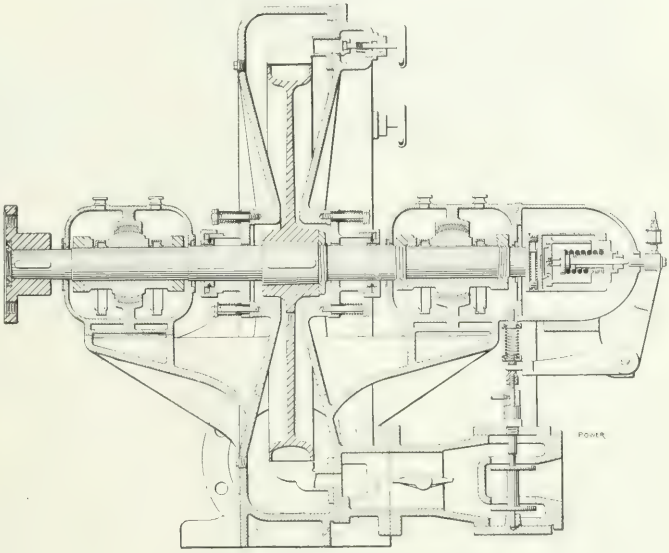


FIG. 5. SECTION STURTEVANT TURBINE

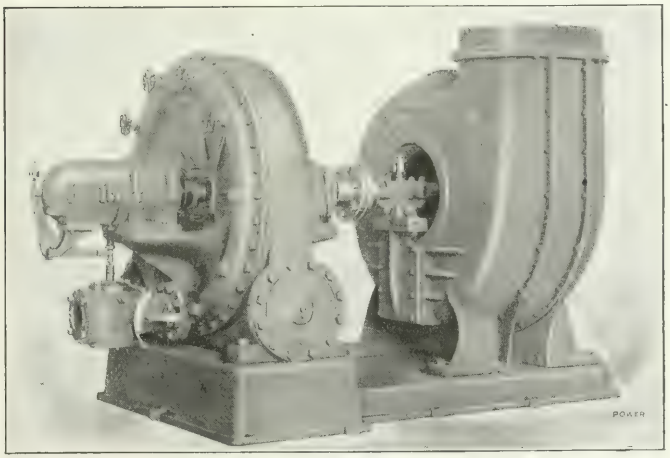


FIG. 6. STURTEVANT TURBINE ATTACHED TO BLOWER

By an ingenious process of milling, in which the cutter is one of a pair of spur gears, the front of the teeth being formed as cutters, the central notch is avoided and the edge of the bucket partition is reduced to a sharp straight line. The same process can, and probably will

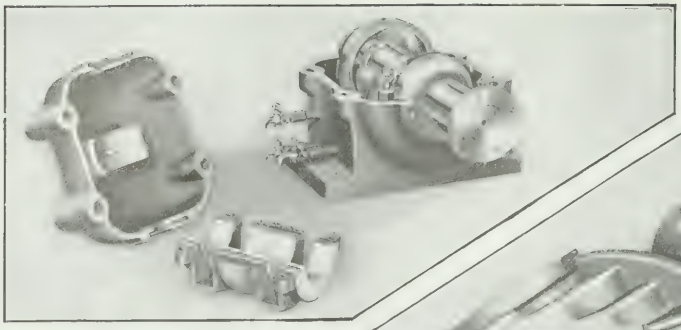


FIG. 7. SPHERICAL BEARING

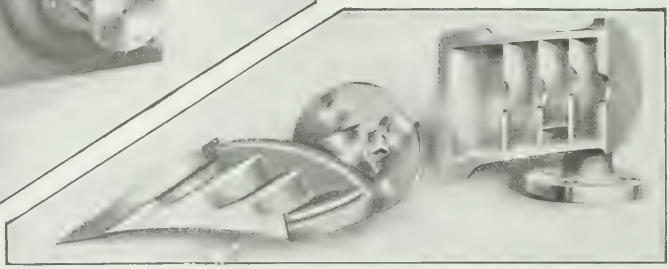


FIG. 3. NOZZLE BLOCKS

be, applied to the milling of the nozzle segments. The side flanges project slightly above the edges of the buckets, shielding them from injury in case of contact. The wheel runs against the faces of the nozzle blocks (as will be seen if the parts shown in Fig. 2 are imagined to be put together) with a clearance of

one side of the exhaust casing (that shown in the front of Fig. 6) and plugged holes in the casing permit inspection of the clearances. Two threaded thrust collars on the governor end of the shaft

The bearings are spherical, self-aligning and split horizontally, as seen in Fig. 7 and in the longitudinal section, Fig. 5. They are lined with an alloy containing 91 parts of tin, 4½ of

SIZES AND CAPACITIES OF TURBINE NOW BUILT

Turbine	Diameter of Rotor in In.	Normal Speed, R.p.m.	Normal Capacity, B.Hp.	Turbine-driven Generating Unit, Kw.	Weight: Turbine Only	Weight: Generating Set, Lb.	Pipes for Maximum Capacity: Steam, In.	Pipes for Maximum Capacity: Exhaust, In.
A 5	12	2000 to 5000	25	3 to 10	600	1500 to 2085	1¼	4
B 5	18	1800 to 4000	50	7½ to 35	1200	2250 to 3970	2	6
C 5	24	1600 to 3500	100	15 to 50	1800	3685 to 5600	2	8
D 5	30	1400 to 3000	150	50 to 57	2400	6600	3½	8
E 5	36	1200 to 2500	200	75	3000	7500	4	10

⅞ of an inch, and as the runner is nicely balanced and the design is not such as to allow of unequal expansion, contact of the running parts or injury to the solid integral rotor appears most improbable. The wheel is highly polished all

make it possible to adjust for any changes in longitudinal register.

The rotor is carried upon a 3.5 per cent. nickel-steel shaft, which is ground after being turned. The brackets for the bearings are of a part with the casing, as shown in Figs. 5 and 6. The stuffing-

antimony and 4½ of copper. They are ring oiling, the rings being of channel-shaped section, with a deflector, shown in Fig. 8, to scoop the oil out of the channel and lead it to the bearings under a considerable pressure due to its velocity.

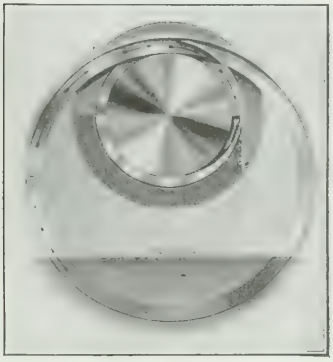


FIG. 8. DEFLECTOR IN OIL RING

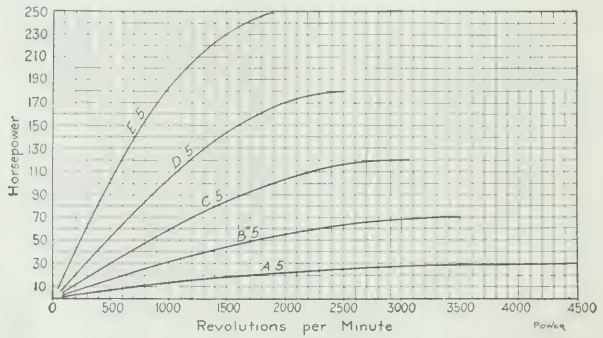


FIG. 9

over, an emery belt running upon a pulley narrow enough to be introduced into the bucket spaces permitting even these interior surfaces to be thoroughly finished. The runner may be inspected in position through the blank flange on

boxes are required to carry only the difference between the atmospheric and exhaust pressures and are of a special floating type, filled with a metallic packing consisting of shreds of an alloy containing 5 parts of antimony, 8 of tin

These turbines are now built in the sizes and capacities shown by the accompanying table.

With a given size of runner the capacity is varied within the limits shown by the table and curves, by putting in more

or less nozzles. The capacity increases with the speed up to the limit of the nozzles, and the attainable efficiency with the greater speed is higher. The diagram, Fig. 9, gives the maximum horsepower which the several sizes will develop at different speeds, with 125 lb. gage initial pressure, dry saturated steam and atmospheric exhaust, and Fig. 10 the steam consumption per brake horsepower at the best load under the same conditions. Fig. 11 gives the steam consumption of the various sizes at different capacities. From these three diagrams it is seen that there is a wide range of choice of a turbine to drive a given load, especially if one is not tied to a given speed. With a given speed, minimum steam consumption will call for the larger and more expensive unit. But if, as in cases where the exhaust is used for heating feed water or in manufacturing processes, the steam rate is of secondary importance, a considerable saving in weight, space and investment may be made by choosing a smaller unit.

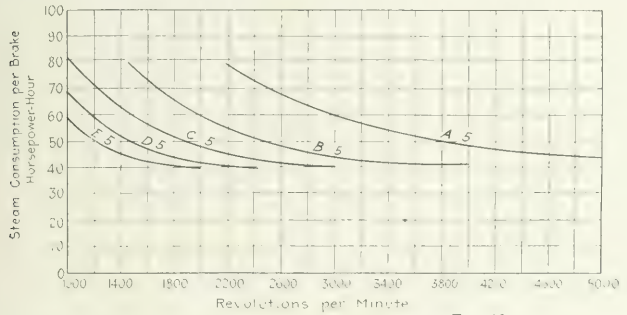


FIG. 10

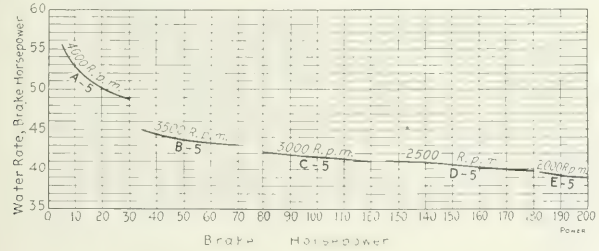
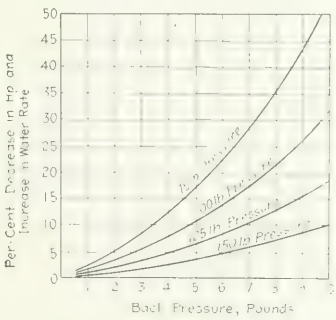


FIG. 11

The supplementary chart at the right of Fig. 10 gives an approximation to the effect upon the water rate of back pressures up to 10 lb., under various initial pressures, the ordinates being decrease in capacity or increase in water rate, expressed in per cent. Moisture in the steam will lower the maximum horsepower and raise the water rate practically 2 per cent. for every per cent. of moisture. For instance, steam of quality 0.97—that is, carrying 3 per cent. of moisture—would lower the capacity 6 per cent. and increase the water supplied to the boiler per horsepower-hour a like amount; for the water supplied but not evaporated is not only practically useless, but is a drag upon the turbine. The maximum horsepower is practically proportional to the absolute pressure, so that it may be easily computed for pressures other than the 125 lb. for which the diagrams are plotted. This water rate would be lowered about 1 per cent. for each 10 lb. additional pressure, and for every 10 deg. of superheat.

A government test of a 36-in. E5 turbine developing 125 hp. noncondensing gave the following results: 1260 r.p.m., 51.5 lb. steam per b.hp., 125 lb. gage pressure, 2 per cent. moisture.

An acceptance test of a 25-hp. generator unit, 2500 r.p.m., 72.6 lb. steam per kw.-hr., 47.6 b.hp., 88 per cent. generator efficiency, 97.5 lb. gage pressure atmospheric exhaust. It was guaranteed not to exceed 50 lb. per brake horsepower.



A 24,000 Horsepower Turbine

From the Schlesischen Elektrizitäts- und Gas-Aktien-Gesellschaft, of Gleiwitz, the present proprietor of the Oberschlesischen Elektrizitätswerke, established in 1896 by the Allgemeine Elektricitäts Gesellschaft, the latter company has ordered for the central station at Chorzow a turbo-generator having a sustained capacity of 16,000 kw., with a power factor of 0.8. With an overall efficiency of about 90 per cent., this would call for the development of 24,000 hp. by the turbine.

The generator is of the well known A. G. E. type, designed to generate current at from 6000 to 6450 volts, and 50 frequency, when running at 1000 r.p.m. Steam of from 12.5 to 13 atmospheres (upward of 200 lb. gage) pressure and superheated to 300 or 350 deg. C. (572 to 662 F.) is to be used. This is a superheat of 188 to 278 deg. F.

In view of the fact that the condensing water is supplied from a cooling tower and deposits a hard scale, the generous amount of 400 sq.m. (4305.6 sq.ft.) of cooling surface has been provided in the condensers, of which there are two of 2000 sq.m. surface each, in order that the turbine may be run, with perhaps a somewhat impaired vacuum, with one condenser while the other is being cleaned. The heating surface consists of 3670 tubes, each about 20 ft. in length, and amounts to 2.69 sq.ft. per kilowatt, or 1.37 sq.ft. per horsepower. Greater accessibility for the expectedly frequent cleaning has been gained by placing the condensers in an annex to the turbine room and upon the same floor level.

Provision is made for handling 4500 cu.m. (about 159,000 cu.ft.) of cooling water per hour. This is something over 400 lb. per horsepower-hour. The pumps are divided into two units, each driven by a direct-connected electric motor, but a steam turbine is installed between them in such way that either or both may be driven by it in case a short-circuit should disable the motor.

The *Zeitschrift für das gesamte Turbinenwesen*, from which our information is derived, does not give any particulars as to the guaranteed or expected efficiency, but says that turbines of nearly as great capacity are being built for the central station at Oberspree, the Berliner Elektrizitäts-Werke and for the Zentrale Reisholz des Rheinisch-Westfälischen Elektrizitätswerke at Essen.

Some Boulton and Watt Letters

By S. W. Chubb

Extracts from a collection of letters at the Watt museum at the Tangye Works, Soho, Birmingham, throwing light upon early British steam engineering practice.

The writer, in an article which appeared in the June 21, 1910, issue of POWER, gave an account of a few of the relics of early British steam-engineering practice, etc., which have been stored by George Tangye in the Watt Museum, a special room forming part of the Tangye Works at Soho, Birmingham. Among the miscellaneous items of this collection may be noted a number of letters bearing various dates, written by Boulton, Watt and their London and Cornish agents, all of particular interest to the engineer, although not necessarily from the purely technical standpoint.

Early Work

As a preliminary, one or two reminders, chiefly as regards dates, may be advisable. In 1765, Watt invented the separate condenser and air pump, turned the atmospheric engine into a steam engine and used the steam jacket. A patent was taken out in connection with these matters in 1769 and it was Roebuck's rights in this patent that Boulton afterward acquired. The patent was specially extended to 1800, and in 1776 expansive working was employed at Soho. In 1781, Watt's second patent, relating to the sun and planet motion, etc., was taken out, to be followed by the third patent in 1782 on the double-acting engine. Then, during 1784 Watt worked out the parallel motion, which was first put into practice in 1785. Probably this will be sufficient to elucidate the matters that follow.

Flywheel Calculation

Boulton's method of calculating flywheels, if a little out of date, may yet afford some interest. It is shown in a letter to James Watt at Truro and dated Soho, Sunday, Jan. 13, 1781. After discussing the sun and planet gear and suggesting that "it is a desirable thing to have the pull of the engine as near the bearing part of the neck of the gudgeon or axis as possible," and showing how he would arrange for this, Boulton continues:

In all Rotative Motions derived from the Reciprocating ones, the Fly must be the equalizer. But let me see if I understand how to calculate ye effect of a fly of any given wt

1st, I will suppose a stout man will raise 1 hogd of water, alias 600 lb. ten feet high in one Min't or 600 pounds one foot high per Mt. wch ÷ by 60″ = 100 lb one ft high per second Thus 16 Men will raise 100 lb to the height of 16 feet per ″ from w'ch height it will fall in one second & will have acquired at ye end of its fall a Velocity of 32 feet. Hence 100 lb in ye rim of a Fly moveing with a velocity of 32 feet per ″ would require the force of 16 Men to stop it in a second but I will suppose ye wt. in our fly to move only 16 ft per ″ & in that case will require only 8 Men to stop it.

Hence a fly of one Ton say 2000 w'd require 8 × 20 = 160 Men. but as a Fly ought to have a sufficient Momentum to prevent the smallest degree of retardation from being perceived, I therefore suppose that where a Mill is required = in power to 160 men that the fly should be 400 lb at least.

When you want to amuse yourself with these subjects do tell me if I am right in my above reasoning — I am aware ye Engine acts ⅓ of ye time.

A Business Letter

The following letter, dated Birmingham, June 18, 1781, addressed by the James Watt Co. to James Woodmason, London, is merely an example of a business letter. The Woodmason firm, of course, were agents for the sale of copying machines:

Birmingham June 18. 1781

To Mr. James Woodmason,
London.

Sir,

We have received your favour of the 13th and are sorry to find that the terms we proposed to you are not agreeable. Your being responsible for the payment was the principal ground of our offer of the 4 per cent on retail & 2% on Wholesale. You must remember that when you first applied for an allowance, when Mefsrs Boulton & Keir were in your Shop about three Months ago, and when you was asked what allowance would be satisfactory, you mentioned —— on all sold retail, and that you would be answerable for the payment of all the machines so sold, and that as to those sold in wholesale, you would not expect any thing for your trouble, but you did not say nor intimate that you would be responsible for the payment of these latter. When we had considered your proposal, we thought as you were well acquainted with the Merchants to whom you had sold machines in wholesale, that it might have been agreeable to you to take their debts also upon yourself for an allowance of 2½ per cent. But since we find our proposal is not agreeable, we shall accede to what you made to us about three months ago, namely, to allow you 5 per cent on all machines that have been sold in retail, upon condition of your being responsible for the payment of all that have been so sold. And we request that you will accordingly draw out your account to this time in that manner, that we may know what ballance to draw for, as we are much in want of cash, and that we may collect any of the wholesale debts that may be due, which will be a very troublesome affair to us to do. To this mode of settling the account of what is past, we agree, but as Mr. Watt came from Cornwall the day before your last letter arrived, we shall say nothing of any future plan, till we have had time to consult him. Only we request that if any applications be made to you for machines in wholesale, that you will please to consult us, or refer them to us, & we should at the same time be obliged to you for your opinion of the persons applying.

We are
Sir
Your obdt. Servts
James Watt & Comp'y

Steam Corn Mill

A letter addressed to Watt by Boulton from Soho on Jan. 18, 1782, and quoted below shows that the idea of a steam corn-mill was in the minds of the firm some time before the celebrated Albion mill, at Southwark in South London, had been started. This engine, which was double-acting, of course, was the first rotating engine with parallel motion erected in London. The scheme had been opposed because it was claimed that steam would throw wind and water-mills out of work, take away employment from the laboring classes, and, most extraordinary of all, reduce the price of bread. From the arguments used against him, Boulton easily deduced that all grinding should be done by hand. The letter also illustrates Boulton's method of calculating the sun and planet motion. It was as follows:

A person is coming from Liverpool Expressly to treat about a Steam Corn Mill & I think we must consent to erect one somewhere before long that we may know how to act in our business & to give answers. I think ye revolving wheel would make a good Corn Mill as you gain Velocity in ye 1st instance. I observe that what ever number of teeth there is in the Spear Wheel. The Central Wheel will make one revolution + that number of, teeth. You desire that I would try two of ye little Engines with 2 of the rotative motions in order to see which looses the least power. Pray how did you think of applying the power? — did you mean to erect 2 pumps of = sizes or what. When you have done with drawings you sent of Rotative Motions & wch I returned to you I should be glad to receive any you can spare. I see a great field in Mill work open to us & I shall make a point of becoming an accurate Mill wright. We have no news here; very Stormy weather & a great Snow, all nature seems torpid

God preserve you and yours
M B

A postscript adds:

In some cases where you want to gain Velocity in the 1st Wheel you may make ye Spear wheel twice ye diamtr of ye Central Wheel by wch means it will make 3 rev'tns for each stroke of ye Engine. I think in general the wheels should be of as large a diamtr as convenient & also that the Mill end of en-

gine Beam should be longer than ye Engine End by wch you ballance ye piston & you get wheels of a larger Diamtr.

Murdock and Symington

The next letter, also to Watt, sent from Truro under date of Sept. 2, 1786, introduces the name of William Murdock, the man whose inventive ability has not altogether received a fair measure of appreciation—the sun and planet gear being still ascribed to Watt. It will be seen that Boulton met Murdock on his way to London for the purpose of taking out a patent for his steam car. The Simmington referred to is W. Symington, who was developing road locomotion as early as 1784, although certain of his proposals had been anticipated by Evans in America.

In or about 1786, Symington showed a steam carriage at Edinburgh, but, it is said, was deterred by the state of the Scottish roads from proceeding and transferred his attention to the use of the steam engine for marine purposes. The small three-wheeled locomotive which Murdock made was actually exhibited at a meeting of the English Institution of Mechanical Engineers, held at Birmingham in 1850. On this occasion, W. Buckle, formerly of the Soho works, read a paper on the inventions of Murdock and, describing the noncondensing steam locomotive, stated that the engine was constructed according to Watt's specifications of 1769.

The copper boiler had an oblique flue through it and a spirit lamp was used for heating purposes. The vertical cylinder was ¾ in. in diameter and had a 2-in. stroke; it was placed on top of the boiler and was connected to a single-arm vibrating beam which, by means of a connecting-rod, actuated a crank on the driving wheel. A double cylindrical slide valve was used, actuated somewhat roughly by means of the beam which in its motion struck shoulders on the valve spindle. The steam was exhausted from the center of the valve.

It will be seen that Boulton was quite aware of the value of Murdock's services and of his possibilities even at the date mentioned. He says:

I arrived at Exeter on Wednesday night and set out from there on Thursday afternoon to sleep at Oakhampton — about 1 mile on this side of Exeter. I met 3 of the Foxes going to a general Quakers meeting at Gloscester and in the same coach was Wm. Murdock. He got out and we had a parley for some time. He said he was going to London to get men, but I soon found he was going there with his steam car to shew it and to take out a patent. He having been told by Mr. Wm. Wilkinson what Sadler had said and he had likewise read in the newspaper Simmington's puff which had rekindled all Wm's fire and impatience to make steam carriages. However I prevailed upon him readily to return to Cornwall by the next days dilligence and he accordingly arived here this day at noon since which he hath unpacked his car and made travel a mile or two in River's great room in a circle making it carry the fire shovel poker and tongs. I think it fortunate that I met him as I am perswaded I can either cure him of the disorder or turn the evel to good at least; I shall prevent a mischief that would have been a consequence of his journey to London.

Murdock's Compressed-air Pump

A letter written from Chasewater, on Mar. 5, 1788, by Thomas Wilson, Cornish agent of the firm, shows what is perhaps not well known, that Murdock had devised a compressed-air pump. The account does not call for any explanation and is confirmed in a second letter in the same hand twelve days later, in which Wilson states that Murdock promises to write to Mr. Watt, "if it does well," anticipating great savings in erecting new engines, in rods, working pieces, buckets and gear "and fifty other things I can fancy both in erection and working."

Murdock's interest in compressed air continued, for in 1802 he used it in connection with the blast engine at Soho to blow cupolas, for driving a lathe, etc., and also for a lift. According to Buckle he had a piston working in a water cylinder 10 ft. in diameter with a lift of 12 ft.; the water being raised by forcing in air from a small blowing cylinder 12 in. in diameter with an 18-in. stroke, which was worked by gearing on the boring mill. He also employed compressed air for the bell system in his own house at Handsworth, a system which Sir Walter Scott copied for Abbotsford. Particulars can be found in the Buckle paper previously mentioned.

Chasewater March 5th 1788

D'r Sir

Enclosed is the acc'ts of Engines &ce for last Month. It was not untill the 28th upon sending to Consol'd Mines to settle the acct's that I found the people at the Mine had ommitted charging your savings in Jan'y; it appears since that this was not done by any order from Mr. Daniell, but as they were not charged in Decr. they took it for granted the ommission was to be continued. I shall mention this to Mr. Daniell tomorrow who I believe is ignorant of it, but am afraid it will be difficult to get it charged next acct. as the Loss will be 10 or £1200. The last Mo was near £800. I went yesterday to see Wm Murdock, he is better, but is still very poorly, he apprehended a Consumption, but I fancy it has been only a Very bad Cold, which is now loosened & is going of. He let me see his new method of raising Water; it is by Compressing Air at the surface which is forced down small pipes, to the Bottom of the Shaft & there communicates with the main pumps & forces up the water. What Machinery he has at the Bottom I cannot tell, only there is no Bucket, but there is a Clack to prevent the water falling Back. His present Machinery, is a Copper Tube of 1 inch Diamr. & 9 Inches Long, in this he works a Wooden Plug; from the side is a Very small Tube, which goes from the Top of his House to his Well 40 feet, & another larger Tube by the side up which the water ascends & runs of continually in an equal Stream. You know I am a terrible poor hand at Mechanics, & therefore will not venture an Opinion; but I think at any rate there should be a patent got for it. He proposes writing to you on the Business. He says Pipes of 3 Inches Diameter will do for forcing down the Air, to work 17 Inch pumps. If so there must be a great saving in erections for deep Mines. He has a very small string which goes down to the Bottom, which he pulls when he sets to work, I suppose to open a Valve. D. Watson has seen it & I believe we are the only people. He says that he does not doubt his Brother being able to put any Engine together & that he will have no objection to agree with you for (3) Years.

I am D'r Sir
Y'r Very H'ble Se't
Thos Wilson

London's 76,000 Tons of Soot

According to an investigation by the London *Lancet*, a medical paper, more than 76,000 tons of soot fell in that city last year. This vast quantity, all of which emanated from chimneys, contained over 6000 tons of ammonia, about 8000 tons of sulphates and 3000 tons of chlorine in chlorides, to say nothing of the carbon and tar.

It is further contended by this paper that the London rainfall in foggy weather is also distinctly destructive to metal surfaces, such as steel stacks, roofs, etc., inasmuch as decided traces of tin and lead were found in the specimens examined.

The heavy soot fall has been attributed to faulty combustion in coal fires. While the contamination of the air is mainly due to factories and power plants in the industrial centers, the fires in dwelling houses, especially in winter, have largely contributed to this serious nuisance.

Utilizing Sudd as Fuel

Sudd, an impenetrable mass of vegetation which obstructs the White Nile River in the Sudan, can be readily converted into fuel by a briquetting process, says the *Scientific American*.

The Sudan government has granted a 10-year monopoly for the manufacture of solid fuel from the sudd, and the concessionaires will have the exclusive right to cut sudd over an area of 93 miles, and 25 acres of land along the banks of the river have been granted on which to erect a factory. The government stipulates that its needs shall have the preference and prescribes a minimum output of 25,000 tons per year. The concessionaires say they expect that 50,000 tons will be produced.

It is Thomas A. Edison's opinion that storage-battery locomotives in Chicago's large terminal yards would do much to abate that city's smoke nuisance.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

Construction and Operation of Carbon Arc Lamps

1209. *How many kinds of arc lamps are there?*

Four general types, namely: constant-potential lamps for operation in parallel on direct-current circuits; constant-potential lamps for parallel operation on alternating-current circuits; constant-current lamps for series connection on direct-current circuits; constant-current lamps for series connection on alternating-current circuits. The only essential differences between these four types are in the construction and operation of the mechanism.

1210. *For what purpose is mechanism needed?*

To control the relative positions of the two carbons.

1211. *How does the mechanism control the positions of the carbons and why is this necessary?*

The carbons must first be in contact with each other, to allow the current to flow through the lamp; then they must be separated slightly to form the arc between their ends. As the ends waste away, the gap between them must be adjusted so as to keep the length of the arc about the same throughout the burning period. The mechanism performs these two operations of "striking" the arc when the lamp is first put into the circuit and regulating the length of the arc during its activity.

1212. *How far apart should the carbons be separated?*

For currents up to 5½ amperes, which is the usual limit of constant-potential inclosed-arc lamps, the separation should be from $\frac{3}{32}$ to $\frac{5}{32}$ of an inch. For 6 to 7½ amperes, usual with constant-current inclosed arcs, the separation is from ⅛ to ¼ of an inch.

1213. *Explain the operation of the constant-potential direct-current arc lamp.*

Referring to Fig. 402, which is a diagrammatic view of a lamp of this type, *M* and *M* represent the two coils of a plunger-type magnet which is provided with a U-shaped armature *A*, consisting of two plungers joined by a yoke. The coils are connected in series with each other and with the brass tube *B* containing the upper carbon; therefore, the current entering the lamp at *P* passes through the magnet coils *M* to the tube *B*, thence down through the carbons and the wire *n* to a sliding contact *F* on the resistance coil *R*, and out at the binding post *N*. When current is first turned on, the magnet coils lift the armature *A*, which slides on the tube *B*. The upward movement of the armature causes a clutch *C*, which is linked to it, to raise the upper carbon rod and "strike" the arc. As the upper carbon is lifted away from the lower one the arc lengthens and its resistance therefore increases

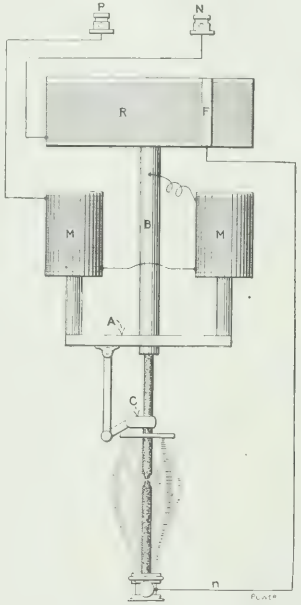


Fig. 402. Diagram of Constant-Potential Direct-Current Lamp

and the current decreases, weakening the magnets, until a point is reached where the weight of the armature and the carbon is just equal to the upward magnetic pull on the armature. As the lamp continues to burn, the carbons become shorter, thereby increasing the length of the arc and reducing the current, which weakens the magnetic pull on the armature; the latter therefore drops until the resistance of the arc becomes normal, when the magnetic pull again balances the weight of the moving parts.

1214. *Does the armature drop suddenly in adjusting the arc?*

No; the "feeding," as it is called, is made very gradual by attaching a dashpot to the armature, and thereby preventing any sudden movement or seesawing.

1215. *Show the actual arrangement of the parts of the constant-potential direct-current arc lamp illustrated diagrammatically in Fig. 402.*

Fig. 403 is a picture of this mechanism. The magnet coils are shown at *M* and *M;* they are wound on brass spools which are attached to the central tube *B*. The resistance coil is shown at *R* and the sliding contact at *F*.

1216. *What is the reason for using the resistance coil and sliding contact?*

To take up the excess voltage of the circuit, to steady the arc and to provide means for adjusting the voltage at the arc. The sliding contact *F* cuts more or less of the resistance coil into the circuit; the more of the coil there is cut

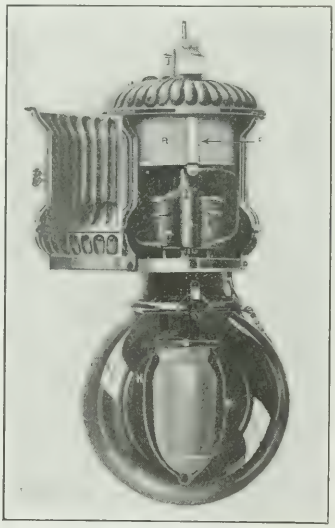


Fig. 403. Constant-Potential Direct-Current Arc Lamp

in, the less will be the voltage at the arc, because of the increased drop in the coil.

1217. *Why is it necessary to adjust the voltage at the arc?*

Because constant-potential circuits are not all of exactly the same voltage, even when rated the same. The actual voltage of a so-called 110-volt circuit may be anywhere from 105 to 115 volts, or even 120. As the arc requires only about

75 volts, some extra resistance is necessary anyhow, and by making this adjustable, the voltage at the arc can be made normal no matter what the actual circuit voltage may be.

1218. *How does the resistance coil steady the arc?*

By the increase in the voltage drop in it when the current through it increases. An increase in the current flowing through the arc would decrease the resistance of the arc because the larger current increases the cross-section of the arc and also decreases the resistance of the carbon particles in the arc. A decrease in the current flowing through the arc, therefore, would increase the resistance of the arc. Consequently, if the supplied voltage was just equal to that required by the arc, and the arc resistance should be increased by the burning away of the carbons, the current would decrease, causing a further increased resistance of the arc, and this would cause a further decrease of current and increase of resistance, with the ultimate result that the arc would be

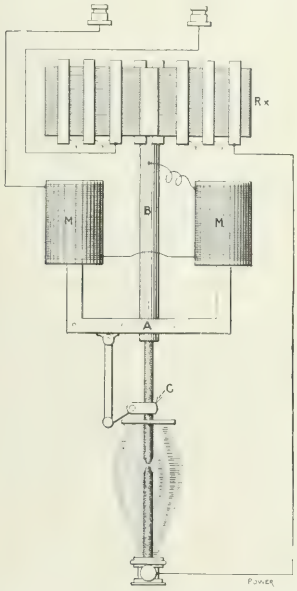


FIG. 404. DIAGRAM OF CONSTANT-POTENTIAL ALTERNATING-CURRENT ARC LAMP

broken. Likewise, an increase of current causing a decrease in arc resistance would still further increase the current and result in a similar unstable condition.

With the wire resistance in series with the arc and properly adjusted so as to make the arc voltage correct when the normal current is flowing through the lamp, a decrease in the current will diminish the drop through the resistance and, as the line voltage remains constant, the voltage across the arc will increase and compensate for the increase in resistance of the arc. Likewise, an increase of current causing a larger drop through the resistance will lower the voltage across the arc and maintain equilibrium.

1219. *Describe the other important parts of the arc lamp in Fig.* 403.

The dashpot *D* is attached to the armature of the regulating magnet for the purpose described already. The upper end of the top carbon is set in a metal socket which is electrically connected to the central tube *B* by a flexible stranded

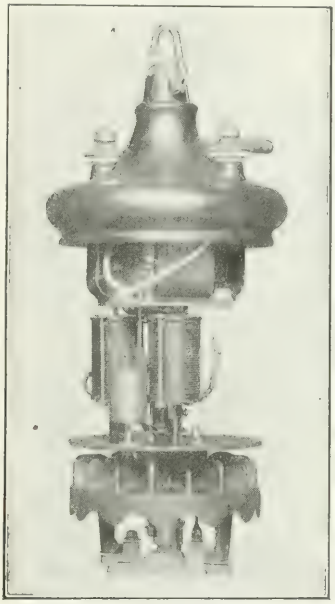


FIG. 405. MECHANISM OF CONSTANT-POTENTIAL ALTERATING-CURRENT LAMP

wire. The inner globe is of clear glass for outdoor service, and semi-transparent so as to diffuse the light for indoor service. It is supported by a spring bail *H* suspended from the cap *G* of the inner globe. An upward projection formed by a few turns of the wire of which the bail is made, rests in a depression in the lower end of the globe and exerts a steady upward pressure which keeps the upper edge of the globe at all points in close contact with the cap *G*.

1220. *Is a constant-potential arc lamp for alternating current exactly like the direct-current lamp?*

Not quite. The alternating-current lamp is provided with a magnet armature made up of thin sheets of soft steel riveted together, instead of solid plungers fastened to a solid yoke; also with a "choke" coil instead of the simple resistance coil of the direct-current lamp. Fig. 404 is a diagram of the parts, in which the "choke" coil R_x is substituted for the resistance coil *R* in Fig. 402 and the laminated armature *A* is shown.

1221. *Why is a "choke" coil used instead of a resistance coil?*

Because it wastes much less energy. A "choke" coil is a coil wound around a soft iron core which forms a closed

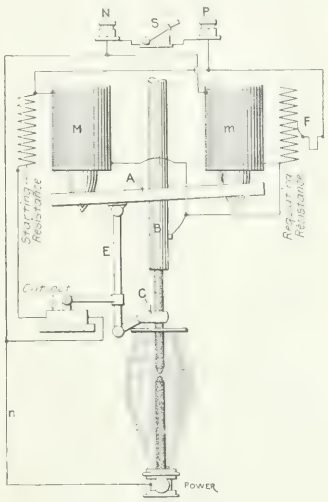


FIG. 406. DIAGRAM OF CONSTANT-CURRENT SERIES ARC LAMP

magnetic circuit. An alternating current passing through this coil produces a rapidly alternating magnetism in its core which induces a counter-electromotive force in the coil. This counter e.m.f. serves the same purpose as the drop in the resistance coil used in the direct-current lamp, but does not absorb any energy. There is some energy loss due to the resistance of the coil but it is very small because the resistance is extremely small.

1222. *If the choke coil wastes less energy than a resistance coil, why is it not used in the direct-current lamp?*

Because direct current flowing through it cannot produce the alternating magnetism in its core necessary to induce a counter e.m.f. in the coil.

1223. *Illustrate a constant-potential alternating-current arc lamp.*

The mechanism of such a lamp is shown in Fig. 405. The general outside appearance is similar to that of the direct-current lamp, Fig. 403. The entire lamp is built around the central brass tube *B*. The top or hood of the case is attached to the upper end and the floor plate *I* and radiating plate *J* to the lower end of the tube. The choke coil is shown

at R_S; the other parts are lettered the same as in Fig. 403.

1224. *What is the radiating plate for?*

To radiate the heat developed by the arc and thereby protect the magnets and mechanism from it.

1225. *How is the mechanism of the constant-current series lamp arranged?*

A diagram of the mechanism and circuits of this type of lamp for direct current is shown in Fig. 406. Two separate magnets are used, one connected in series with the arc and another connected in shunt to the arc. The series magnet is shown at *M* and the shunt magnet at *m*. The armature *A* in this lamp is pivoted to the central tube *B* instead of sliding on it, and it is tilted one way by the series magnet, to lift the clutch *C* and the upper carbon, and pulled the other way by the shunt magnet to release the clutch and drop the carbon. The switch *S* is used to cut the lamp out of circuit by short-circuiting the terminals.

1226. *Explain the operation of the mechanism in detail.*

When the lamp is first put in circuit, the armature *A* is tilted to the position shown, by the weight of the clutch *C* and its linkage; the clutch is then open, allowing the upper carbon to rest on the lower one. The current passes from the positive terminal *P* to the series magnet *M*, the starting resistance and the regulating resistance and divides between the three, but most of it goes through the magnet and the carbons and the return wire *n*, because that path has the lowest resistance. The magnet *M* lifts the armature and clutch, and the latter engages the upper carbon and carries it upward, striking the arc between the two carbons. As soon as the link *E* starts upward, it opens the contacts of the cutout and that part of the current which at first was shunted through the starting resistance now passes through the carbons. As the upper carbon is lifted away from the lower one the lengthening of the arc increases the voltage across the carbons and this increases the strength of the magnet *m* which is connected in parallel with the carbons; when the arc is at normal length, the pull of the magnet *m* is sufficient to prevent the magnet *M* from lifting the carbon any farther. As the carbons burn away, the lengthening of the arc shunts more current through the magnet *m*, and the magnet *M* is correspondingly weakened; the armature is therefore tilted slightly the other way, lowering the clutch *C* to the point where it trips and feeds the upper carbon downward.

1227. *What is the starting resistance for?*

To prevent the cutout from putting a dead short-circuit across the lamp when it is closed by the extreme downward travel of the link *E*. Such a short-circuit would make it impossible for the lamp to restart its arc automatically when next cut into circuit.

1228. *What is the need for the cutout?*

To close the circuit around the lamp if the upper carbon should hang up or burn so short that it could not be fed downward any farther. In either case, the arc becomes excessively long and the magnet *m* pulls its end of the armature up so far that the cutout is closed and cuts the rest of the lamp mechanism out of circuit.

1229. *What is the regulating resistance for?*

To adjust the strength of the lifting magnet *M* and thereby regulate the length of arc necessary for the feed magnet *m* to overcome the lifting magnet and feed the carbon. The regulating resistance is in shunt to the series magnet coil and shunts more or less current out of it,

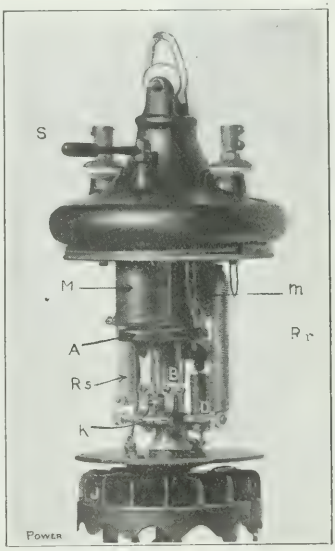


FIG. 407. MECHANISM OF CONSTANT-CURRENT SERIES ARC LAMP

according to the position of the sliding contact *F*.

1230. *Illustrate the actual mechanism of the constant-current arc lamp represented by the diagram.*

Fig. 407 shows the mechanism of this type of lamp. The cutout is shown at *K*, the starting resistance at R_S and the regulating resistance at R_r. The other parts are lettered the same as in Fig. 406.

1231. *Are all constant-current lamp mechanisms like the one just described?*

Not in all the details, but they all work on the differential principle; that is, a series magnet pulls the carbons apart and it is opposed by a magnet coil connected in shunt to the arc. In some lamps the shunt coil opposes the series coil magnetically instead of mechanically. Magnetic opposition is obtained by winding the series and shunt coils on the same core; any increase in the current in the shunt coil weakens the magnet as a whole, because the magnetizing effects of the two coils are in opposition to each other. In most cases, however, the magnets are separate and their pulling efforts are opposed mechanically, as in the lamp described.

1232. *Is the series alternating-current lamp like the direct-current lamp?*

Yes; in all essential features, except that the magnet cores and armatures are laminated instead of solid and choke coils are used instead of resistance coils, as explained in the discussion of constant-potential lamps.

LETTERS

Mr. McGinnitie's Rattling Exciter

I have had several cases of rattling such as Mr. McGinnitie described in the Jan. 2 issue, and in each case I found it due to the oil rings. The bearings being worn, the small pin which bridges the oil-ring slot to keep the ring in place would be found to be either broken off or bent up so that the ring had a chance to jump up and down on the shaft, due to the vibration permitted by the loose bearing. When the guide pin was replaced, keeping the ring down on the shaft, the rattle stopped.

L. M. JOHNSON.

Glenfield, Penn.

Mr. McGinnitie's exciter trouble reminds me of the case of a 25-hp. motor I once installed. It was used to drive a large fan and as first installed had a very poor foundation of timber and planks and the vibration was ascribed to that condition, but after being placed on a concrete foundation it did no better. Although it had been paid for, the manufacturer sent a man to investigate the trouble and remedy it if possible, but he did not succeed in locating it.

Finally, someone suggested that the shaft was not round. This was hardly taken seriously, but as everything else that anyone could think of had been tried, the shaft was taken out and measured with a micrometer; it was found to be 0.002 of an inch out of round. The maker was apprised of this fact and supplied us with a new shaft; after this was substituted for the old one, no further trouble was experienced.

This might possibly be the trouble with Mr. McGinnitie's machine; it would be worth while to caliper the shaft, at least, to see if it is dead round.

VICTOR JUMP.

Caledonia, Ohio.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

World's Production of Crude Petroleum

The world's production of crude petroleum for the five years from 1906 to 1910, inclusive, in barrels of 42 gal., by countries, was as follows:

The production in 1910, as a simple arithmetical process will show, was, in round numbers, 13,753,835,000 gal., aggregating about 100,815,600,000 lb. This quantity would fill a pipe 50 in. in diameter extending entirely around the surface of the earth at the equator, and would maintain in continuous service, 24 hours per day, for a year Diesel-type engines delivering 23,017,000 hp.

Country	1906	1907	1908	1909	1910
United States	126,493,936	166,095,335	178,527,355	183,170,874	209,556,048
Russia	58,897,311	61,850,734	62,186,447	65,970,350	70,336,574
Galicia	5,467,967	8,455,841	12,612,295	14,932,799	12,673,688
Dutch East Indies	8,180,657	9,982,597	10,283,357	11,041,852	11,030,620
Roumania	6,378,184	8,118,207	8,252,157	9,327,278	9,722,958
India	4,015,803	4,344,162	5,047,038	6,676,317	3,137,890
Mexico	.....	1,000,000	3,481,410	2,488,742	3,332,807
Japan	1,710,768	2,010,639	2,070,145	1,689,563	1,930,661
Peru	536,294	756,226	1,011,180	1,316,118	1,330,105
Germany	578,610	756,631	1,009,278	1,018,837	1,032,522
Canada	569,753	788,872	527,987	420,755	315,895
Italy	53,577	59,875	50,966	42,388	42,388
Other countries (estimated)	30,000	30,000	30,000	30,000	30,000
Total	212,912,860	264,249,119	285,089,615	298,326,073	327,472,256

The Cost of Oil Power

By Chas. H. Herter

Referring to the discussion on the above subject in the issue for Jan. 2, the following explanation seems to be warranted in order to prevent the performance of the engine in question from being taken as representative of oil engines in general. The writer is familiar with the engine referred to, but is not interested commercially in any engine or power whatsoever.

The oil engine at New Haven is a Hornsby-Akroyd, of the type of English origin which has been on the market over 20 years. The compression is usually between 50 and 60 lb. per square inch, the maximum pressure after ignition 140 to 170 lb. and the mean effective pressure 40 to 45 lb. The exhaust valve is not water-cooled and the incoming air is heated by passing over it, thereby reducing the weight taken in. In the case of the New Haven engine the average brake horsepower is reported to have been 90, and so the fuel-oil consumption on the basis of oil weighing 7½ lb. per gallon figures up 1.59 lb. per brake horsepower-hour.

With a simple low-pressure engine of this type a fuel economy approaching that of a high-compression engine with adequate air supply and fuel injection at beginning of the power stroke cannot reasonably be expected, but even taking into account the load factor of $\frac{90}{125}$ or 0.72, the oil consumption should not have exceeded 1.1 lb. per brake horsepower-hour, the consumption at full load being guaranteed not to exceed 1 lb., and having been found in some sizes to be less than 0.9 lb. It is possible that too much heat was carried off by the jacket water. At light load the discharge temperature can safely be carried higher than at full load.

It will be clear from the foregoing that the oil engine at New Haven is not in the same class with the more modern high-compression De La Vergne and Diesel oil engines, the fuel consumption of which is but one-half of that of the type built years ago.

The overall efficiency of the plant in question could perhaps be improved by utilizing the waste heat by means of a water heater utilizing the heat of the exhaust gases and that usually lost in jacket water. About 3600 B.t.u. per brake horsepower-hour have been recovered at full load from the exhaust and 5000 B.t.u. from the jacket water of a natural-gas engine. To what extent the carbon carried in the exhaust would reduce the efficiency of the surface of such heater remains to be seen. In the Hornsby-Akroyd engine the heat radiated by the glowing vaporizer cannot be recovered, of course.

California's petroleum production in 1911 is estimated by David T. Day, of the United States Geological Survey, as reaching a possible 83,000,000 bbl. as compared with 73,010,560 bbl. in 1910. The increased production was chiefly from the Sunset and McKittrick region, from the pools already developed in 1910.

The Oil Power Vessel "Jutlandia"

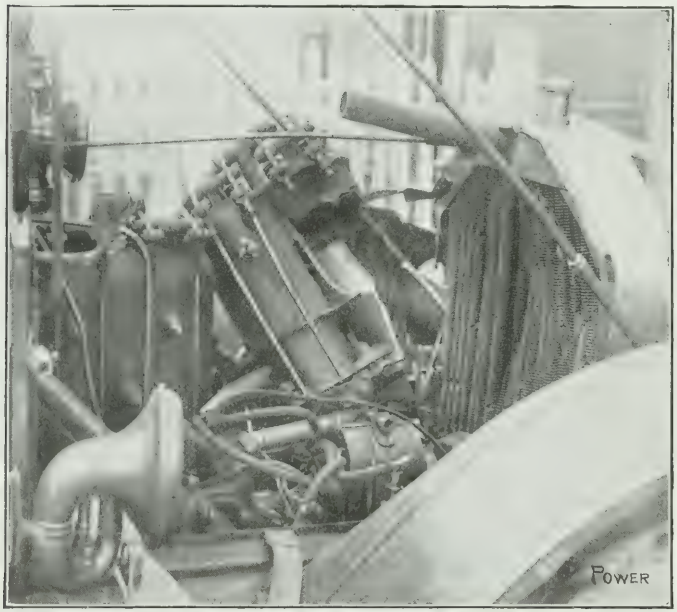
The twin-screw oil-engined vessel "Jutlandia," recently built by a British firm to the order of the East Asiatic Co., of Copenhagen, was launched on Dec. 11. Her dimensions are 384 ft. length, 53 ft. 3 in. breadth, 30 ft. depth. Her displacement is 10,000 tons at 23 ft. 6 in. draft, and the dead-weight capacity 7000 tons, with a registered gross tonnage of 5000. She will be supplied with two sets of Diesel oil engines capable of developing 3000 indicated horsepower. She will have three masts, and the exhaust gases from the engines will be led up inside the mizzen mast and exhausted at a height of 48 ft. above the deck, so that no separate stack will be needed. A noteworthy and economically very important feature is that the machinery space is only about a third of that which would have been necessary for steam engines and boilers, and that the absence altogether of boilers and boiler casings leaves a large amount of hold and 'tween-deck space for the storage of cargo and the accommodation of passengers. The siren, on the mainmast, will be operated by compressed air. It is expected that the "Jutlandia" will be ready for speed trials some time next month.—*Exchange.*

LETTERS

Two Gasoline Engine Wrecks

In the Jan. 9 issue, L. Earle Browne and R. E. Wall describe two gasoline-engine smash-ups. In Mr. Browne's case the first question which occurs to one is: Did the explosion take place above or below the piston? If it took place above the piston, that is to say, in the combustion chamber, it may have been due to the ignition of a very rich mixture while exactly on, or very nearly on, dead center. The last time the engine was stopped, the driver may have switched off but left his throttle wide open, which would allow the engine to take several inspirations of a rich mixture, the gasoline content of which would condense on the cylinder walls and piston head. On cranking over for starting up the next time—the time of the accident—the throttle would be fairly wide open and the mixture obtained therefrom, in addition to that already in the cylinder, may have been sufficiently explosive to cause the wreck. It will be observed that the engine had been cranked around twice, through a complete cycle.

If, however, the explosion took place in the combustion chamber, one would expect the pieces to have been blown more vertically than horizontally, as they apparently were. Also, it is hard to see why the bottom half of the crank case should have been blown into "a hundred or more pieces." I am inclined to think that the explosion took place in the crank case and that No. 1 and No. 4 pistons were descending at their maximum velocity at the time of the explosion, the tendency then being to destroy the crank case and to wreck No. 1 and No. 4 cylinders. No. 1, being the weakest, went in this case. The pieces would also be thrown in the manner described in this event.



MR. BROWNE'S AUTOMOBILE-ENGINE EXPLOSION

Then comes the query: How did the explosive mixture find its way into the crank case? The answer is simple. Many automobile owners are troubled by gasoline leaking past the pistons and mixing with the lubricant in the crank case, causing trouble by thinning the oil with which it becomes emulsified. Now the engine had, in this case, been standing for four days. This left ample time for the gasoline and the oil to separate out, the gasoline floating on the top by virtue of its lower specific gravity. Its presence being accounted for, next comes the question of how the mixture got ignited. As the engine had been standing for four days, the cylinder walls and internal mechanism generally had been drained comparatively dry of oil. Given one or two stuck or badly worn rings and an ignition in one of the cylinders, and it is possible that a tongue of flame may have found its way between the stuck rings and the dry cylinder wall and fired the mixture in the crank case. Alternately, the accidental striking of one metal part by another metal part inside the crank case may have caused a spark which ignited the explosive mixture.

With regard to Mr. Wall's smash, he says that when the engine got "fairly started" he turned the ignition timing to the running position. This sounds rather as if he shifted the timing lever from starting up to full-load position all at once. If so, an ignition on center, or early, may have caused the engine to give way along the line of least resistance as he suggests. Ignition timers should always be gradually moved on gasoline engines, and the engines should be more than "fairly started"—as I read it—before the spark is set to occur in advance of center.

JOHN S. LEESE.

Manchester, Eng.

On page 54 of the issue of Jan. 9, L. Earle Browne asks for opinions as to what caused the explosion of a gasoline engine. On looking at the photograph it will be noticed that the most damage was done beneath the explosion chamber, and Mr. Browne says that the crank case was broken into a hundred or more pieces and that both Nos. 1 and 2 cylinders were torn away from the bottom casing.

My theory is that in some way an explosive mixture got into the crank case and exploded there; this could be accounted for by there being a hole or flaw through the piston face. This mixture would have a tendency to fire from a spark at the spark plug in the combustion chamber. On the other hand, some one may have injected some gasoline into the crank case, thinking to play a joke on the operator and not realizing the possibility of serious consequences.

However, I am sure the explosion was caused by gas in the crank case as, if any of the parts, such as the connecting-rod or crankshaft had been bent, there would not have been so many broken parts. It would be well to thoroughly examine the piston and cylinder internally to find if there was any flaw showing where gas could escape into the crank case. If no flaw is found, it might be worth while to look over the electric connections thoroughly to find out how a spark got into the crank case.

G. H. HANDLEY.

Newburgh, N. Y.

I showed Mr. Browne's article to Mr. James H. Fennon, an expert on gas engines and a mechanical engineer of rare ability, and asked him to solve the problem. The engine was evidently a water-cooled machine, and in Montana at this time of the year the climate is more than cold; Mr. Fennon suggests that the water jackets froze with the intense cold and cracked the cylinder in a hundred places, and when the gasoline explosion occurred, it simply blew out these cracked pieces and wrecked the machine.

STEPHEN C. BROWN.

Natick, Mass.

Curing Hot Bearings

Several weeks ago on account of low water our station was called on to take our street-railway load. We have two 800-hp. gas engines and were doing some repair work on them; therefore we were not in good shape to run. However, we managed to get both engines going, but in about 30 minutes the left-hand main bearing on No. 2 engine was smoking hot. We had a very big load and could not shut down without overloading the other engine. After trying every kind of "dope" I could think of, without any improvement, I slowed the engine down as slow as it would run and tightened the quarter boxes a little at a time until they were jam up, keeping them well flooded with cylinder oil and a little flake graphite. I let it run that way for a few minutes and then began to loosen up a little on the boxes. After it cooled down to a running temperature, I gave the engine the load again and that was the end of that box getting hot.

J. B. LINKER.

Charlotte, N. C.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Cold Storage of Furs and Fabrics

By E. F. Tweedy

The placing of furs and such fabrics as carpets, tapestries, clothing, woolens, etc., in cold storage to protect them against insects during certain portions of the year, is now generally recognized as the most satisfactory method of dealing with this important problem. The annual loss arising from the destruction of the above classes of merchandise by the moth and the beetle cannot be even approximately estimated, but the yearly toll is unquestionably tremendous, and any means of reducing this loss is therefore worthy of serious consideration.

The first storage warehouse in this country to undertake the cold storage of furs, carpets and other fabrics was apparently that of the American Security & Trust Co., of Washington, D. C., which provided cold-storage facilities for goods in 1894.

For two years thereafter, the manager of the cold-storage department of this company, Albert M. Read, assisted by Dr. L. O. Howard, chief of the bureau of entomology of the United States Department of Agriculture, carried on a series of extremely interesting and valuable tests to determine the effects of various temperatures upon the larvæ of the moth and beetle. These were probably the first tests ever conducted along similar lines, and the results secured served largely as a basis for the subsequent commercial development in the use of cold storage for the protection of furs and fabrics.

The cold storage of furs at first was opposed by many furriers, who had derived a considerable income from caring for their customers' furs during the summer months, such care usually involving a frequent brushing and shaking of the furs, separated by intervals during which they were packed away with camphor, tar paper or some other moth-repelling substance.

But such opposition gradually disappeared and today the leading furriers either operate their own cold-storage vaults or else rent storage space in cold-storage warehouses. The latter are rarely so located as to be conveniently reached by the furriers' patrons, and this is doubtless the reason the majority of the furriers and department stores maintain their own refrigerated rooms for storing furs.

In the experiments referred to it was found that any temperature below 45 deg. F. was sufficient to keep the larvæ of the moth and the beetle from doing any damage, although the larvæ were capable of sluggish movement at a temperature as low as 42 deg. F. Below 40 deg. all movement was suspended and the larvæ became entirely dormant, while above 45 deg. activity of the larvæ began and increased with each degree up to 55 deg. when a normal, active condition was reached.

It was found that the larval condition was the one in which the damage occurred, as the grease and animal juices in the fiber of the fur and wool serve as food for both the moth and the beetle larvæ while these insects are passing through this stage. The larvæ, it was found, could withstand as low as 18 deg. F. for a long period without harmful effects and they changed back from a dormant to an active condition when the temperature again became normal. However, if repeatedly exposed to considerable changes in temperature, the larval vitality was considerably reduced —a fact which should cause a winter composed of alternating periods of cold and mild weather to be followed by a summer of decreased insect life. Also that the miller and the beetle were soon killed when subjected to temperatures below 32 deg. F. and that they gradually died if exposed to between 32 and 40 deg. F.

While these investigations showed that cold-storage rooms for preservation of furs and fabrics may be kept at 40 deg. F. with perfect safety, the temperatures most commonly carried in cold-storage rooms today range from 20 to 26 deg. F. At these lower temperatures the furs retain a fresh and glossy appearance, and the flexibility of the skins is preserved by a lessening of the evaporation of their natural oils.

Two methods of applying mechanical refrigeration to the cold storage of furs and fabrics are in general use; one is the direct system and the other the indirect, each system possessing advantages as well as disadvantages. In the direct system the refrigerating coils—either arranged for direct expansion or for the circulation of brine—are placed within the storage room itself, being mounted upon the side walls or ceiling, or upon both. The indirect system comprises an air-cooling room or bunker space in which are the refrigerating coils, this space being entirely separate from the room to be refrigerated but connected with it by a system of ducts through which the refrigerated air is circulated by means of a fan.

The advantages of the direct system are that it is somewhat cheaper to install and also to operate: the first, because of the elimination of the air-cooling chamber and air-circulating fan, although this is partially offset by the somewhat greater cost of the piping for the cooling coils; the second, because it is unnecessary to operate an air-circulating fan, which requires an appreciable amount of energy. With either system, using brine as the cooling medium adds materially to the first cost of the installation, and likewise increases the cost of operation due to the necessity of constantly circulating the brine.

The use of brine arises from the fear of a leak in the ammonia piping, with a consequent damage to the goods in storage. Where the ammonia piping is carefully installed and tested before being placed in operation, danger from the leakage of ammonia gas is probably not great, as the successful operation of the large number of plants employing ammonia as the refrigerating agent bears witness.

However, in view of the heavy financial responsibility usually involved where furs in any quantity are held in storage, this question is of considerable importance, and where ammonia is employed as the refrigerating agent, the indirect system, with brine as the secondary cooling medium, offers the greatest amount of security against damage from the refrigerating medium itself. The indirect system is further advantageous in freeing the storage space of the moisture which collects as frost on the piping and which melts and drips from the pipes if the temperature rises above the freezing point. The air in the storage space is therefore drier where the indirect system is used; this is also an advantage, provided the percentage of moisture is not reduced too far, a condition which can easily be prevented.

One of the arguments advanced against the indirect system is that it involves an increased fire risk, as the movement of the air in the storage space might tend to fan a fire if one should occur. This belief was considerably strengthened by a fire, involving a heavy financial loss, which occurred in the fur cold-storage room of a large department

store in Brooklyn a few years ago. The origin of this fire was unknown, but it has been generally contended that the system of air circulation that was in use was responsible for the fire.

As a result, the New York Fire Insurance Exchange made certain recommendations as to the manner in which the indirect system of refrigeration for fur-storage rooms should be installed. These recommendations call for the air duct or ducts to be equipped with automatic dampers, arranged to be controlled by fusible links properly installed; the blower or fan to be equipped with an automatic controller arranged to be operated either by electric thermostats having a low fusing point, or by thermometers having proper attachments installed within the cold-storage room, and that these devices be adjusted to operate the controller on the blower so that when the temperature rises to 100 deg. F. the blower will shut down. Where these recommendations are observed, this system apparently offers no material increase in fire risk over the direct system.

TABLE 1. CHARACTER OF INSULATION

	B.t.u. per sq.ft. per 24 hr. per deg. dif. between outside and inside temp.
Double ⅞-in. boards and paper, 1-in. air space, 5-in. sheet cork, paper and ⅞-in. board	0.90
Double ⅞-in. boards and paper, 1-in. air space, 4-in. sheet cork, paper and ⅞-in. board	1.20
Two ⅞-in. boards and paper, 8-in. mill shavings, two ⅞-in. boards and paper	1.35
Same slightly moist	1.80
Same damp	2.10
Double ⅞-in. boards and paper, 4-in. granulated cork, double ⅞-in. boards and paper	1.70
One ⅞-in. board and paper, 3-in. sheet cork, paper, one ⅞-in. board and paper	2.10
One ⅞-in. board, 6-in. patent silicated strawboard (air cell), finished with thin layer of patent cement	2.48
Four double ⅞-in. boards with paper between (eight boards in all) and three 8-in. air spaces	2.70
One ⅞-in. board, paper, 2-in. sheet cork, two ⅞-in. boards and paper	3.00
Two ⅞-in. board and paper, 1-in. sheet cork, two ⅞-in. boards and paper	3.30
Two ⅞-in. double boards and two papers, 1-in. hair felt between	3.32
One ⅞-in. board and paper, 2½-in. mineral wool, paper and ⅞-in. board	3.62
Two ⅞-in. boards and paper, 1-in. air space, two ⅞-in. boards and paper	3.71
One ⅞-in. board, 2-in. pitch, one ⅞-in. board	4.25
One ⅞-in. board, 1-in. pitch, one ⅞-in. board	1.90

The refrigerating requirements for given outside temperature conditions, and for a given maintained temperature within the cold-storage space, are, of course, directly dependent upon the insulation provided for the floor, walls and ceiling of the room to be refrigerated. As the insulation in different installations varies greatly in its effectiveness in limiting the passage of heat from the outside to the inside of the refrigerated space, it is impossible to even approximately estimate the refrigerating requirements for a given volume of cold-storage space without a knowledge of the character of the insulation to be employed.

This is particularly evident when one considers that with some of the different combinations of insulating materials in ordinary commercial use variations may be obtained in heat transmission from less than 1 to nearly 5 B.t.u. per 24 hr. per square foot of exposed surface for each degree of difference between the inside and outside temperatures. Table 1 shows the approximate number of B.t.u. transmitted per square foot per 24 hr. for each degree of temperature difference for several different types of insulation commonly met with in practice.

The number of cubic feet of refrigerated space per ton of refrigeration naturally varies with the size of the space refrigerated, other conditions remaining the same, inasmuch as the exposed surface through which the gain of heat occurs does not increase in proportion to the increase in the volume of the refrigerated space. It is also somewhat affected by the system of refrigeration employed; that is, whether the direct or the indirect system and whether brine is used as a secondary cooling medium. As in all other refrigeration problems this question of insulation is of paramount importance, and the saving in the cost of power required will almost invariably pay a large return upon the money invested in a high grade of insulation.

Table 2 shows the capacity of the refrigerating plant installed, the cubical contents of the space refrigerated, the volume of refrigerated space and the total exposed surface per ton of refrigerating plant capacity, together with the system of refrigeration employed, for a number of electrically driven refrigerating plants used in connection with the cold storage of furs and fabrics.

Table 3 gives some figures on power required for motor-driven refrigerating plants used exclusively for the cold storage of furs. In cases 2 and 4, the compressor motors were not separately metered prior to June, so that the kilowatt-hour consumptions for the preceding months were not available. In cases 1 and 3, the consumption figures cover an entire year, although these plants were in actual operation only during some seven or eight months.

It is somewhat surprising to observe how low the load factor is in these plants, even during midsummer. Based on the rating of the motor which drives the compressor, plant 1 operated at rated load for only 10 per cent. of the time during July, the month of greatest consumption; while for the entire period (May to October, inclusive) it operated at its rated capacity only 6½ per cent. of the time.

Upon the same basis, plant 2 showed a 30 per cent. load factor for September, and a 27 per cent. load factor for the seven months ending with December. Plant 3 had a load factor of 16 per cent. during June, and a load factor of 12 per cent. for the period beginning with March and ending with October; while plant 4 had a maximum load factor of 21 per cent. during July, and 16 per cent. for the seven months ending with December. The load factor thus based upon the rated capacity is, of course, dependent upon the relation of the size of the plant to the actual refrigerating requirements.

TABLE 2. CAPACITY OF PLANT AND VOLUME OF REFRIGERATED SPACE

Capacity, Tons Refrigeration	Motor Driv. Refrig. Plant, Hp.	Contents Storage Space, Cu.Ft.	Cu.Ft. Storage Space per Ton Refrig.	Sq.Ft. Surface (Floor, Ceil., Side Walls) per Ton Refrig.	System
50		155,000	3,100		Indirect—brine coils
20	35	60,000	3,000	748	Indirect—ammonia coils
15	25	40,500	2,700	651	Indirect—ammonia coils
10	15	32,700	3,270	805	Direct—ammonia coils
4	7½	5,720	1,430	569	Direct—ammonia coils

While it is quite usual to provide refrigerating capacity sufficient to permit the plant being closed down during 12 or 14 hr. out of the 24, even at a time when the refrigerating requirements are at a maximum, it would appear that all of these plants, with the possible exception of No. 3, have capacities considerably in excess of those actually needed to meet present requirements.

It is somewhat difficult to accurately predict what the consumption of electrical energy will be for a proposed fur-storage plant unless there is detailed information as to the character of the insulation to be employed and unless the type of refrigerating plant that is to be installed is known. The method of operation will also affect the consumption materially, as, for instance, whether manual or thermostatic control of the compressor is employed. From an examination of the data given in Table 3, it would appear that the kilowatt-hours per square foot of exposed surface (including floor, ceiling and side walls) varies, for these particular plants, from a little under 1 to about 3, this variation being due not only to the character of the insulation employed but to the

type of plant and to the method of its operation.

The operation of plant 3, in Table 3, is briefly described as being typical of the modern fur-storage plant. It is operated about eight months of the year, usually from Mar. 1 to Nov. 1, but sometimes for a longer period, according to the weather conditions. The storage vaults contain about 60,000 cu.ft., and about 15,000 fur garments are stored during the summer months. The ammonia expansion pipes are located in a cooling room containing approximately 2700 cu.ft. A system of ducts connects this room with the cold-storage vaults, and the air is kept in circulation by means of a blower operated by a 4½-hp. motor.

Brine is allowed to trickle over the ammonia pipes to keep them free of frost, and its circulation is effected by means of a 1-hp. motor-driven centrifugal pump. This brine is not employed as a secondary cooling medium, as in the brine system proper, but simply for the purpose stated. In thus keeping the external surfaces of the cooling coils free from frost, the transfer of heat from the air of the cooling chamber to the expanding ammonia gas within the coils is facilitated and the operating efficiency is thereby increased.

During the winter months the plant is not operated as there are few furs in storage and the outside air is sufficiently low to maintain them in a satisfactory condition. During this period the blower circulates the outside air through the vaults, which are thus maintained at about 10 deg. above that of the outside air.

After the plant is started in the spring and until it is shut down in the fall, the temperature in the storage vaults is never allowed to rise above 32 deg. F. During this period the average temperature is approximately 20 deg. F., ranging from 26 deg. in the early morning to about 14 deg. just before the plant is closed down in the afternoon. From 6 p.m., when operation is ordinarily discontinued, until 8 the next morning, when it is usually started again, the rise in temperature is about 12 deg. On Monday mornings, the plant having been shut down over Sunday, the temperature is generally about 30 deg. F.

The storage vaults and the cooling room are well insulated. The floor insulation consists of 1 in. of paving cement, two 2-in. layers of cork, a layer of felt, 6 in. of ordinary cement and finally 3 ft. of slag cement. The ceiling comprises ½ in. of plaster, four 2-in. layers of cork, a 4-in. air space, and above this a layer of firebrick. The walls are composed of firebrick with cork insulation embedded in tar. From the actual kilowatt-hours consumed during the summer months, taken in connection with the recorded mean temperatures of the outside air during the same period, it would appear that the average loss through the floor, ceiling and walls of this vault is approximately 1.25 B.t.u. per square foot per 24 hr. per degree difference in temperature, which shows that a high quality of insulation has been provided.

TABLE 3. POWER REQUIRED BY COMPRESSORS OF VARIOUS CAPACITIES

Month	1 4-ton Comp., belt-driven, 7½-hp. motor; direct system; ammonia coils Consump., Kw.-hours (Comp. only)	2 10-ton Comp., chain-driven, 15-hp. motor; direct system; ammonia coils Consump., Kw.-hours (Comp. only)	3 20-ton Comp., belt-driven, 35-hp. motor; indirect system; ammonia coils Consump., Kw.-hours (Comp. only)	4 15-ton Comp., belt-driven, 25-hp. motor; indirect system; ammonia coils; thermo. control; 5 hp. motor drives fan for circ. air. Consump., Kw.-hours Compressor	 Fan
Jan.			1,872		
Feb.			3,056		
Mar.	5		3,344	.....	
Apr.	193		3,384	3,195	649
May	574	2,088	3,224	3,550	535
June	507	2,876	3,264	3,390	513
July	396	2,708	2,656	3,165	424
Aug	387	2,945	936	2,594	363
Sept.	68	2,693		1,490	204
Oct.	1	2,550		586	81
Nov.		2,087			
Dec.					
Total	1,931	18,547 (7 mos.)	21,736	17,970 (7 mos.)	2,769
Kw.-hours per yr. per sq.ft. surface (comp. only)	0 85	2.3 (7 mos.)	1 45	1.84 (7 mos.)	

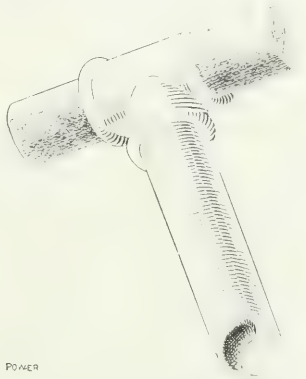
In New Zealand, boiler explosions are almost unheard of. Reference to the last annual report of the Inspection of Machinery Department discloses the remarkable record made in that country. "During the 21 years I have been in the department," says the chief inspector, "only two explosions have occurred. This is a very fine record for in that time over 10,000 boiler inspections have been made and boiler pressures have increased 50 per cent." This high efficiency is in marked contrast to the numerous explosions that yearly occur in the States.

LETTER

Removing Rubber Packing

Now is the time when refrigerating engineers should start their annual repairs and for this work the accompanying letter may be of some use. I have just removed the coils from a condenser and absorber of the shell type and found it slow work drawing the lead and rubber rings with regular packing tools from around the tails of the coils. The repairmen from the shops may have some tools for quick work, but I have never heard of them.

After several experiments with hooks and chisels, I started on a different plan which was very successful. Take a piece of pipe one size larger than the tail of the coil and, when not large enough to slip over the tail easily, split it on one side far enough to allow it to reach the bottom of the recess.



TOOL FOR REMOVING PACKING

At one end of the pipe drill a ¾-in. hole clean through and with a hacksaw cut out the pipe, as shown in the drawing, leaving the end of the pipe with two projections very similar to the old "hook-tooth" saw. With the side of a tee on the other end and a short stick or pipe through the run of the tee as a handle, the tool is used as an auger.

In working the lower ends of the coils take off the tee and use a pipe wrench to turn the tool. Care should be used when cutting the lead at the top and the bottom of the recess that the tool does not "hog" in and bite off more than can be pulled out. When cutting the rubber the work is easier if the tool is lifted out occasionally to allow the chips to fall out of the holes. To remove the packing from sixteen 1¼-in. and four 1-in coils I estimated the time as three days. I made two tools, one of 1¼-in. pipe for the 1-in. coils and one of 1½-in. pipe, which I had to split for the 1¼-in. coils, and was through with the job on the second day.

W. C. REED.

Pittsfield, Mass.

LETTERS

Temperature of Ammonia Compressor Discharge

Referring to D. E. Aden's comments in the Dec. 12 issue, page 898, on T. L. D.'s questions on the above subject, I submit the following:

The temperature of the gas in the discharge pipe of an ammonia compressor is not directly related to the condenser pressure, but is more related to the back pressure and to the temperature of the suction gas at the compressor, as on these two (suction temperature and pressure) depend the quality (degree of wetness) and the quantity of gas to be compressed.

E. N. Friedmann, retiring president of the American Society of Refrigerating Engineers, submitted the following tentative figures, in a paper read before the St. Louis meeting of that society, in October, 1911:

Back pressure gage, lb. per sq.in.	Temperature of single-acting comp., deg. F.	Discharge gas, double-acting comp., deg. F.
5.0	200	300
15.0	240	287
25.0	213	253

The temperature of the suction gas is not given in the table, but Mr. Friedmann mentioned in the same paper that the suction-gas temperature should be close to the saturation temperature at the given pressure.

As to the dissociation of ammonia gas, authorities claim that it does not begin to dissociate until a temperature of 900 deg. F. is reached. This is far higher than any temperature existing in refrigerating machinery.

ALBERT J. GILL.

Washington, D. C.

Ammonia Packing Gives Trouble

In the plant where I am employed there is a 10 and 4 by 10-in. ammonia pump used in connection with an absorption refrigeration system. We have a good deal of trouble in keeping the ammonia end of the piston rod packed. The packing lasts but a short time, being eaten out, so to speak, making it necessary to pack the pump very frequently. Ordinary ammonia packing is used. It comes in both solid and diagonally split rings, and in packing the pump the rings are alternated. We tried taking the spool out and filling the entire box with packing; also, inserting rings of lead between the rings of packing, but with no success in either case.

If any of the readers of POWER have had like difficulties, I would like to know how they were remedied.

H. G. GIBSON.

Washington, D. C.

Nugent Oil Filter

The new oil filter recently gotten out by William W. Nugent & Co., 220 West Huron St., Chicago, Ill., is illustrated herewith.

Referring to Fig. 1, oil is poured into a tray *D*, or if the filter is connected to

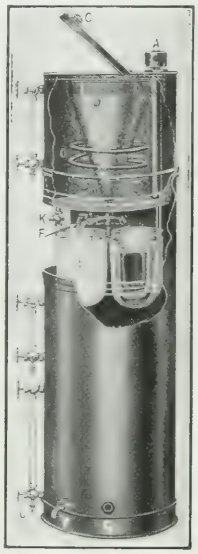


FIG. 1. NUGENT OIL FILTER

an oiling system, the water and oil is piped to *A*. In the bottom of this tray is an opening about which an inverted cone of reticulated material is placed. The heavy or coarse particles of grit are here removed and separated. The oil

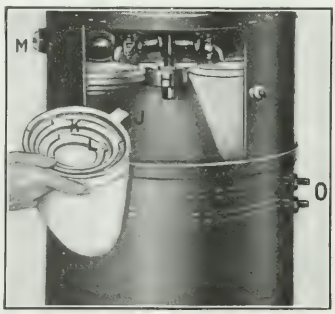


FIG. 2. REMOVING A FILTERING BAG

passes through the drips *F* into three funnel-shaped filtering bags *I*.

There are four sets of these bags and they are attached to three independent rings or holders to each set. Each ring with its respective bag may be removed for cleaning independent of each other. Each set of bags or rings is provided with a hook *J*, Fig. 2, that engages a hub *H* which, with the four sets of bags, rotates at will on the center support. Consequently when the two sets of bags in front become foul and will not filter, they may be thrown around to the back of the filtering chamber and there left to drain until they can be cleaned. The door is then closed.

The operation of the oil filtration may be seen and the filtering bags cleaned or examined at any time without interfering with the workings of the filter. An electric-light globe *M* is also provided for the proper illumination of the filtering chamber. Steam coil *O*, Fig. 1, encircles the filtering chamber, but the oil never comes in contact with this coil. After the oil is filtered through the bags, it passes on into the water-separating chamber, where the water is automatically separated from the oil by precipitation and flows to the sewer through a suitable connection.

The upper water glass shows when there is water in the oil, before it overflows to the sewer. The gage-glass *U* indicates the amount of clean oil in the filter; the faucet *V* is for drawing off the clean oil, and the opening *Q* is a pipe attachment for an oiling system. The valve *K* lets the water out of the water chamber and is for cleaning. About 2 in. of water should always be in the water glass to seal the automatic water-separating device and keep it in working order.

By removing the tray in the top of the filter and the bags attached to this tray, the filter can be seen down to the bottom and examined and cleaned.

Roybel Packing

A new metallic packing has recently been placed on the market by the Roybel Packing Co., 30 Church St., New York City. Anti-friction metal is used as a base for its composition to which is added a liberal quantity of graphite, also a small percentage of asbestos fiber, in order to thoroughly mix the metal and the graphite. It is said that the metal has the desired density, heat resisting, wearing and noncorrosive quality necessary for a successful packing, and that the liberal use of graphite in its composition improves its wearing qualities and supplies the necessary lubrication to the piston rod.

This packing is made for use with steam, air, gas, ammonia and water and for packing-valve stems, of various kinds.

Under the auspices of the Coal Smoke Abatement Society of England, an international smoke-abatement exhibition will be held in London, Mar. 23 to Apr. 4. Preliminary prospectuses of the exhibition will be loaned by the United States Bureau of Manufactures to those interested.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

An Evenly Balanced Power Plant

To operate it economically and successfully, an industrial plant, such as a steel works, lumber or textile mill, must of necessity be evenly balanced as to its machinery and the capacities of its different departments. For instance, in a plant where the raw material is worked up through the various phases of its manufacture into the finished product, it would show poor judgment to have one of the intervening departments capable of handling twice the amount of material that the preceding one could furnish or the following one take care of.

In a similar way and for the same reasons, a power plant must be evenly balanced. While there may not be many phases or departments in the manufacture of power, there are always two points that must receive consideration, the fuel intake, or boilers, and the power output, or steam engines, generators, etc. Where a new power plant is to be installed it is an easy matter to so design and select proper equipment that everything will harmonize as to capacity, steam pressures, voltage, etc., so that a perfect balance will result, but making alterations or additions to an old station is quite a different matter.

The rapid progress made in power engineering during the last few years has made it very difficult to keep an old plant uptodate in every respect. Not many years ago 100 pounds steam pressure was considered very good for an average boiler house, while today 150 to 185 pounds is quite common. A power plant built several years ago, therefore, usually has engines suitable for only comparatively low pressures, and should new boilers be necessary to replace the old ones they should be selected with this fact in view. Of course, boilers built for high pressures could be installed and operated at such pressures as the engines would determine, but unless conditions indicate that a higher steam pressure can be used in the near future, it is doubtful if it would pay to tie up a lot of money in the more expensive high-pressure boilers. On the other hand, suppose one of the engines gives out and must be replaced, then the low steam pressure available will deter the purchase of a high-pressure, high-power economical machine. This naturally prevents the owners from obtaining the economical results that modern practice should give, and is particularly true of steam turbines, where high pressures are always desirable.

In considering the purchase of a low-pressure steam turbine to utilize the exhaust steam from a reciprocating engine, it is always advisable to thoroughly examine the engine to make sure that its probable life will justify the addition of the turbine. This point is sometimes overlooked in the great desire to increase the power supply at very little additional operating cost, with the result that after two or three years the engine is ready for the scrap pile and the question arises as to what is the best thing to do. Investigations then usually result in finding that the purchase of the turbine was made without careful consideration of the situation and that the only thing to do now is to get a new engine to work in combination with the turbine, whereas it might have been possible to get a machine more suitable for the conditions in the first place and, perhaps, at considerably less outlay of money.

In such instances it is always well to look ahead a year or two and do a little figuring to see if the economies effected, as well as the better operating conditions that would result, will not justify a broader consideration of the question at hand. It has even been found that it is real economy to relegate to the scrap pile some particular machine or equipment that might still be in good condition but has been superseded by something that realizes a greater decrease in the cost of production and, consequently, a greater saving in the investment. It is also a fact that any particular part of a power plant that tends to retard the op-

eration of the rest of it at its highest efficiency, is an expense that should be avoided by bringing this part of the equipment up to the same standard as the rest.

Get-Rich-Quick Schemes

Anything which would materially diminish the cost of production of power would be of incalculable value in this industrial age. This is so obvious even to the layman that it opens an inviting field for the exploitation of discoveries and inventions which are to revolutionize present methods and make barrels of money for all concerned.

Every little while we receive from an interested or derisive reader a prospectus, catalog or newspaper advertisement of some wonderful invention or discovery, stock in which is obtainable at extremely moderate prices and profits upon which are imminent and enormous.

If these things were worth one-half what their promoters make them out to be, they would not be peddled out in this fashion. There is plenty of money waiting for profitable investment and any man with an invention or discovery of real value in the power field can capitalize it to any reasonable amount when it is indorsed by competent engineers.

A frequent subject of this kind of exploitation is the rotary engine. It is not difficult to persuade the man unversed in mechanics that there are enormous losses involved in the roundabout way in which the reciprocating engine gets its power to the shaft; that the dead center is a source of frightful waste, and that the "gain of leverage" in the rotary type is an important advantage.

The knowing ones appreciate that the dead center and the reversal of motion involve no loss aside from their slight effect on bearing friction, and that no power was ever made or gained by leverage. If the rotary engine ever beats the reciprocating engine in steam economy it will be because of less friction, less clearance and less interchange of heat between the steam and the containing surfaces.

The rotary engine promises no large improvement in steam efficiency. Whatever advantages this type may possess are to be found in high rotative speed, lightness, freedom from vibration, adaptation to certain purposes and perhaps low cost of manufacture. It is impossible to condemn it as one would a perpetual motion, for one may be evolved which may find a profitable if limited field of application; but they will never realize the rosy dreams of their inventors, who usually gain the opprobrium which goes with a lot of disappointed stockholders rather than the proud place by the side of Watt and Corliss in the inventors' hall of fame to which they are already elevated by the prospectuses, most of which read like mechanical joke books to the initiated.

When you are tempted to invest in anything of this kind, get the advice of a competent mechanical engineer. It may cost you a few dollars, but may save you many.

Another favorite get-rich-quick scheme is the magical compound which, sprinkled over the coal pile, will make it burn without smoke and evaporate more water than it is supposed to be responsible for. From a Salem (Mass.) paper we learn that the American Carbonine Co. is now visiting North Shore manufacturers for the purpose of demonstrating the merits of "Carbonine." They mix a pound of chemicals in a bucket of water, spray the solution on the coal pile, shovel the coal into the furnace and make the victim think they save him 25 to 30 per cent.

It is needless to say that if there is any chemical which will do this it costs more than the coal that it would save and that the game is older than "Kem-Kom" and the host of other names that the various compounds so advanced have borne. We advise the tanners of the North Shore not to get in too deeply before seeking competent advice.

England's Alarming Discovery

With loud acclaim, a London press dispatch of Feb. 5 announces the discovery by the British Admiralty of the fact that a recent German engine development threatens Britannia's naval prestige.

This "perfected type of internal-combustion engine, which will make the dreadnaught obsolete and give Germany control of the seas," turns out to be the Diesel engine.

In a letter to the New York *Times* of Feb. 7, Mr. George Westinghouse says that there is no reason to fear an oil-engine navy. In its present stage of development, he contends, the internal-combustion engine cannot operate with the same freedom from accidents and interruptions as does the modern steam engine, turbine or reciprocating. But danger awaits the navy of that country which is depending upon the development of this type of engine rather than availing itself of the present class of machinery.

That the value of artificial ventilation is practically ignored by the lay public, and its many hygienic and commercial advantages are regarded with hostility by most supervisors of public institutions and large office buildings, are very good reasons why ventilating engineers should redouble their efforts to make plain their necessity in engineering.

Operators and owners of isolated plants are frequently criticized for not knowing the value of their plants and not having the necessary data upon which to base the fixed charges. If we are to judge by the testimony of some of the New York Edison Co.'s officials in the rate hearing now going on before the Public Service Commission, it would appear that the small plants are not the only offenders in this respect.

The British Admiralty appears to have quite successfully solved the problem of corrosion in condenser tubes. Notwithstanding the large number of British warships in service, the number of cases of pitting or localized corrosion is very small, and frequently tubes last from ten to twelve years.

In the Atlantic fleet, 620 men learned to swim in one week—they were compelled to do this. If you compel yourself to do something to increase your efficiency, it may mean better wages, a more responsible position.

Two cats were killed at the last boiler explosion in New York City. Men would have shared the same fate had they been in the same place.

Sand for a hot box and "sand" (and grit) in an engineer—well, you can draw a ready inference.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Pump Diagrams

The accompanying diagrams were taken from one side of a 16, 28 and 6½ by 24-in. compound, duplex pump running noncondensing and exhausting direct to the atmosphere. The pump runs at a speed of from 32 to 34 strokes per minute, and pumps against a head of 300 to 400 lb. The boiler pressure ranges between 105 and 110 lb. per square inch. The pump makes an actual stroke of but 22½ in.

PUMP DIAGRAMS

I run two 100-hp. return-tubular boilers when running the pump at 32 to 34 strokes per minute, and burn from 32 to 40 bbl. (of 42 gal. each) of oil of 15.6 deg. Baumé, each 24 hours, as fuel. The feed water enters the feed pump at 138 deg. F.

I would like to hear what some other engineer thinks of the plant's efficiency and the accompanying diagrams.

FRANK WILLIS.

Reward, Calif.

Dashpot Repair

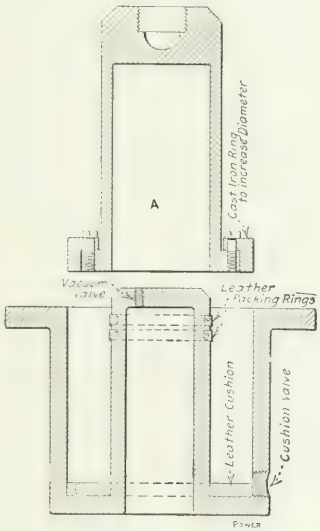
The accompanying sketch shows how a set of dashpots which had acted badly since the engine was first erected, were improved. It was found that when originally bored they had not been cleaned up all around, which prevented the plunger from fitting close enough to confine sufficient air to cushion it.

To overcome this trouble the engineer had to partially break the vacuum in the vacuum chamber, which caused a bouncing action to the plunger. The pot was trued up and two grooves for leather rings were turned as shown in the lower sketch. An ell-shaped ring was turned and secured with cap screws to the plunger. Leather strips were fitted in the grooves and a disk of leather was placed in the bottom of the pot to prevent the plunger making a disagreeable noise when the two metallic parts came in contact.

This change resulted in nice working dashpots.

The quarter boxes on this same engine gave trouble. The adjusting bolts extended down behind the wedges with a right-angle bend and fitted into holes in the wedges which were tapered ¼ in. per inch. This extreme taper caused the wedge to slide down, springing the wedge bolts, sometimes breaking them and causing the shells, wedges and cap to move and wear the frame jaws.

This trouble was overcome by fitting a bar between the wedge top and the cap and tightening the cap-bolt nuts down as hard as prudence allowed without breaking the cap. This makes some trouble when it is necessary to take up the bearing, but this is not done oftener than once in 12 or 18 months.



HOW THE DASHPOT WAS REPAIRED

Two young engineers have been broken in on this engine and each melted out a main bearing. In one case the shop was very busy and a shutdown was not to be thought of, as it was only three weeks away from the annual shutdown for stock taking. I concluded to cut oilways in the shaft. This enabled the engine to run until it was convenient to raise the shaft and rebabbitt the box.

Shaft grooves should be cut in the shape of a number of crescents joined together spirally around the shaft, but never parallel with the shaft or a flat surface will wear on the shaft. Care must be taken to dress the metal near the oil groove to a true circle, either with a fine file or an oilstone. If the shaft is not smoothed properly, the ridges will scrape the bearing metal and ruin the box.

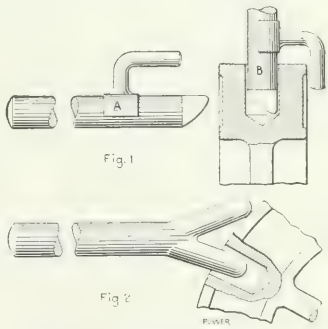
I believe that oil is distributed better when the grooves are in the shaft than when they are in the babbitt.

J. O. BENEFIEL.

Anderson, Ind.

Fool Proof Barring Lever

With the small high-speed engine it is a very common practice to supply a barring lever, as shown in Fig. 1. The guard *A* is fixed on in various ways. While this lever may answer the purpose, it is far from being fool-proof, and one engineman I know spent some weeks nursing several smashed toes before he realized that the lever should not be used as shown at *B*.



A much more reliable lever, which I came across recently, is shown in Fig. 2. As will be seen, it is simply a double-pointed bar, easily forged to shape and quite fool-proof. Either point may be inserted in the barring hole of the flywheel; there is no wrong way. If an attempt is made to apply it sideways, as at *B*, Fig. 1, on applying any pressure it swings to the correct position or the reverse and comes out.

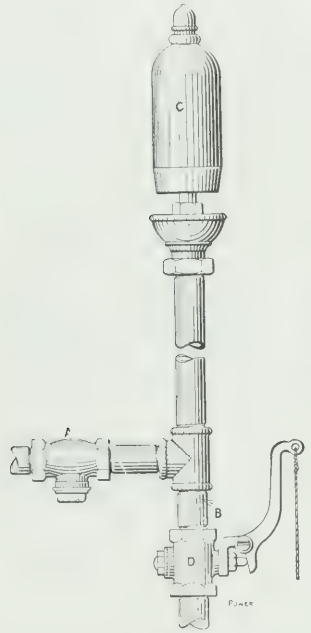
J. PARNELL.

Belfast, Ireland.

Drain for Exposed Steam Whistle

In many factories the whistle valve *D* is in the boiler room while the whistle *C* is outside the building, of course, and several stories higher.

In such cases there is a small valve attached to the steam pipe, operated by hand, which is opened after the whistle is sounded and closed while sounding. Sometimes the operator forgets to open the drain valve, and if the whistle valve *D* should leak ever so little, the steam pipe will gradually fill with water. When the lever is pulled there is a great splatter of water blown from the whistle



ARRANGEMENT OF CHECK VALVE FOR DRAINING WHISTLE PIPE

for some seconds before it will begin to sound. If the weather is cold the water in the pipe is liable to freeze and burst the pipe.

In the accompanying figure it will be seen that a small check valve is attached upsidedown with the outlet side toward the steam pipe. When the lever is pulled the steam pressure rushing into the pipe will close the check and keep it closed until the lever valve closes. The pipe is then empty of water and the pressure suddenly drops, allowing the check to open. A small drip pipe can be attached to *A* and run to some convenient point if desired

HAROLD BEECHER.

Toronto, Ont.

Design of Water Intake

The writer was engaged to operate a certain plant before it was completed, and consequently he watched its construction closely with a view to making any change that would improve operating conditions.

One such change had to do with the water intake. This was intended to be built as shown in Fig. 1, taken from the

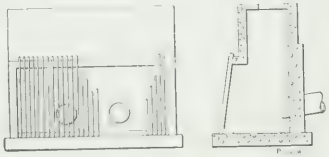


FIG. 1. ORIGINAL DESIGN OF INTAKE

consulting engineer's sketch. This arrangement would be all right at tidewater or for a large lake, but it is not a suitable design to be used in a small stream running through many miles of woodland. The engineer, on pointing out

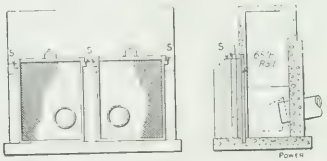


FIG. 2. IMPROVED DESIGN OF INTAKE

the conditions that might be expected and asking to be allowed to change the construction, was told by the superintendent: "Go ahead and build it to suit yourself." Fig. 2 shows how he built it. The piers, extended out as shown,

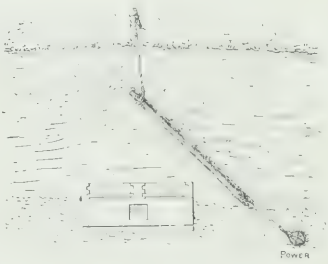


FIG. 3. BOOM FOR DIVERTING LEAVES

were provided with slots *S* for the reception of the screens, the pier in the center being reinforced by a steel rail, in order to guard against possible damage when struck by the large masses of ice which are carried along with considerable speed during the spring thaws.

After the plant had been in operation some time, it became necessary, on account of the water level being lowered, to place elbows on the pipes. This was done without interfering with the operation of the plant in any way. For several weeks this fall, great quantities of leaves were carried along. A boom placed in the position shown in Fig. 3 helped to divert a great many and it was necessary to keep a man at the screen almost continually as it would be completely covered in an hour. In spite of this extreme condition, not an instant's delay in operation occurred.

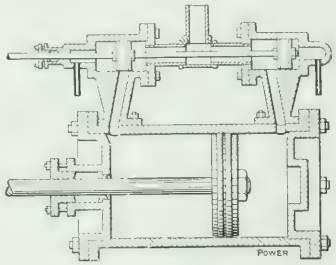
O. M. SAMUELS.

Albany, N. Y.

Supplementary Exhaust Valves

In a certain woodworking factory there is an 18x28-in. double-eccentric, slide-valve engine, running at 125 r.p.m. that has been in service for 12 years.

About five years ago a new engineer took charge, who closely investigated verything pertaining to the mechanical branch of the plant. In due course of time he indicated the engine and found that at normal load the back pressure amounted to 13 lb. He conducted a



SUPPLEMENTARY EXHAUST VALVE APPLIED TO CYLINDER

series of tests, in order to ascertain the cause, but arrived at no conclusion until he measured the exhaust port and found that it was too small.

An extended correspondence between the engine builders and the firm who owned it ensued, which terminated by the engine company as good as advising the owners to get a new engineer, as the present one did not know what he was talking about.

The engineer kept his job nevertheless, and devised a set of supplementary exhaust valves, which he figured would reduce the back pressure. He tried to induce the owner to finance his scheme, explaining that while the improvement would not cost much it would reduce the fuel bill about 25 per cent.

During the past five years he used every possible argument, but the old man would not be convinced until it was necessary to install new machinery to the extent of about 30 hp. Since the engine was already overloaded, and it was impossible to put up a new engine

while running, owing to the already cramped space, and the fact that they could not afford to shut down, the old man told the engineer that the only way out of it was to put in an electric motor and run it on central-station power for the overload. The engineer, not having much love for the central station, told the old man that if he carried out this plan, he would quit.

By this time the old man thought well enough of him to keep him, and after a lengthy argument he told the engineer to try his supplementary exhaust scheme. The result was that the back pressure was reduced to about 3 lb., thereby increasing the power of the engine about 36 hp. and doing away with the necessity of installing a motor and paying the monthly power bills. The expenses for the improvement amounted to about $95.

The accompanying sketch will explain the working of the supplementary exhaust valve. An opening of 7 sq.in. was made through the cylinder crown into the clearance space. Over this opening or port the valve casting rested, the lower part of which conformed to the shape of the cylinder. The upper part of the casting consists of two cylindrical sections, the larger one containing the piston valve, the smaller one being drilled for a drip pipe, to lead off any steam that might leak by the piston. The exhaust pipe, which is flanged to the valve heads, branched out from the center as shown. Both pistons are on the same rod, which is attached to the main exhaust-valve slide, and are therefore actuated by the exhaust eccentric.

VICTOR BONN.

New York City.

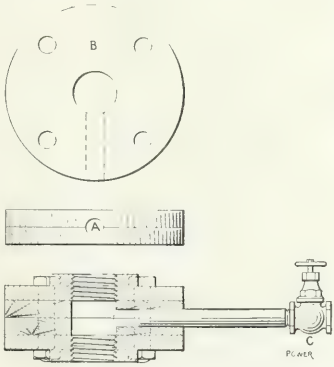
Backwoods Steam Fitting

Some days ago I was in a regular Rip Van Winkle of a steam-power plant away back in the woods. The husky in charge of the outfit looked as if he did not know that he was alive, but that was where my observations led me astray. Another husky, noticeable for the size and height of his boots, strolled up and said: "Ike, I want to use some steam for a few hours over across the room to limber up some wood from the ice."

"O. K.," said Ike, "she will be there in a giff."

I had learned before this that Ike's tool outfit for pipe-work consisted of several disreputable-looking pipe wrenches and some chisels, and I wondered how he was going to get in that pipe.

There was a 2-in. steam pipe close at hand connected with flanges. Ike removed the bolts and separated the flanges, placed a ¼-in. board between them, and marked the holes and circumference of the flanges on it with a lead pencil. Then he walked over to a bandsaw, and in a few minutes had two wooden flanges cut out as shown at *B* in the accompanying figure. He placed them together between the jaws of a wooden vise and bored a hole so that half of it came in the face of each board as at *A*. There was room to separate the iron flanges without danger of springing, and he placed the two wooden flanges between the iron ones.



WOODEN FLANGES FOR STEAM-PIPE CONNECTIONS

He then placed a nipple with a valve attached as at *C* in the hole, and used four long bolts to connect all together tightly.

When steam was turned on there was no sign of a leak. Next, he screwed a length of pipe into the valve and this brought the other end over to where the steam was wanted. The whole operation did not take up 15 min.

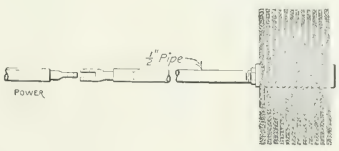
Ike told me that he often ran in a temporary steam pipe in this style, but he had to make new wooden pieces each time, as the ones in use warped very much after they were removed and allowed to dry.

J. JAMES.

Toronto, Ont.

Flue Brush Extension Rod

In taking charge of a plant some time ago, I found that the distance between the boiler-room wall and the boiler fronts was a little over half the length of the



EXTENSION ROD FOR FLUE BRUSH

tubes. When cleaning the tubes the fireman pushed in one section of the brush handle and then screwed the other end in a coupling, which made slow work of the job.

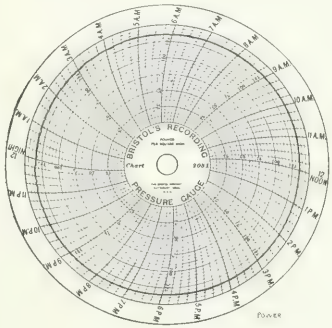
On looking over the scrap pile I found some old duplex pump-valve rods and welded them in each section of the brush handle, as shown, using the same bolt to secure the joint. By making a double joint the end rod can be moved sidewise as well as up and down.

ROBERT B. MASTERS.

Mount Vernon, Mo.

Good Record from Pressure Gage

The inclosed chart was taken from our recording pressure gage. I consider it a record of a very exceptional performance. There are six water-tube boilers in the plant, and the chart was taken from the main steam header in the engine room. It shows what firemen can



AN IDEAL STEAM CHART

do by careful attention and education. The load ranges from 200 to 1400 kw. during the 24 hours' run. The boilers are equipped with mechanical stokers, in which Youghiogheny screening coal is burned. The chart is duplicated nearly every day.

L. C. TOPPING.

Fargo, N. D.

Knock in Boiler Feed Pump

The piston rod of an outside-packed boiler-feed pump stripped its thread on the end that screwed into the crosshead, also the thread in the crosshead, and a new rod and crosshead were made.

When they were made and assembled the pump developed a very hard knock in the inward end of the side having the new rod. The rod was supposed to be of the exact length of the old one and the crosshead travel when running slowly coincided with the marks on the frame.

There was no way to change the valve setting as the valve stem was turned out of stock large enough to form the tappet and was connected to the rocker-arm by a link; there was no way to change the length of the piston rod. The engineer tried placing washers with one side cut out between the tappet and valve ears to reduce the lost motion and thereby shorten the stroke on that end, but

it did no good. Then the wrought-iron rocker-arm was bent so as to shift the valve, but the pound still remained.

There was a ¼-in. hole from the steam port into the exhaust port to gradually release the cushion after the exhaust port was closed. The one on the end where the pound occurred was plugged with soft copper which caused a higher cushion or compression on that end and made the pump run quietly except at high speed, and it was run in this manner for some time.

Shortly after I took charge of the plant, in removing the piston to examine the rings, I found that the piston showed evidence of striking the front head. I pushed the piston up against the head and measured the distance from the piston to the end of the cylinder and subtracting the length of the stroke I found there should be ½ in. clearance on each end. The distance rods and the plunger were disconnected, the rod taken out and a collar made ⅝ in. thick to fit the rod between the shoulder and the crosshead which made the rod ⅝ in. longer. The copper plug, which stopped the knock but did not remove the cause, was taken out and when the pump was started it ran as quietly as one could wish. Upon looking up the sketch of the new rod given to the machinist, the length was given as 1¼ in. too short.

J. C. HAWKINS.

Hyattsville, Md.

Rhode Island Coal

It may be of interest to know that the Rhode Island Coal Co. has passed into the hands of a receiver. I will add that among some of the "philistines" in this vicinity there has been a feeling that it might be a good purchase for starting an industry for making a fireproofing material out of the product.

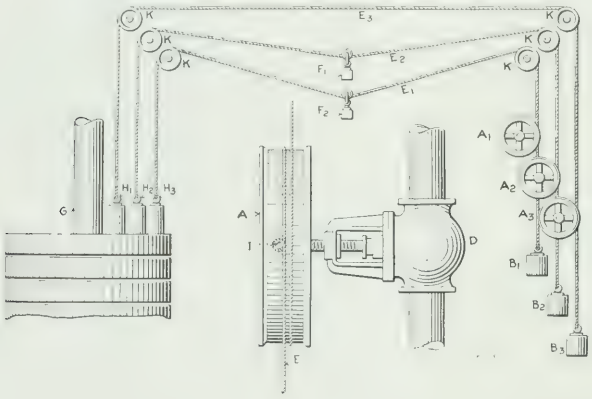
WARREN B. LEWIS.

Providence, R. I.

Step Bearing Pressure Regulator

The accompanying illustration shows an automatic regulator for step-bearing pressure pumps which is simple and reliable, has been in use for three years and has given entire satisfaction. It is here shown in connection with three pumps.

In the steam line of each step-bearing pump and above the hand throttle (although the drum may be placed on the hand throttle, but this is not advisable) is placed the automatic throttle *D*, which is opened and closed by drum *A*, around which is wound one or more times the rope (or cable) *E*, which is looped around the pin *I*, to prevent slipping. On the lower end of rope E_1 is a weight, such as B_1, which closes valve *D* if it is not over-balanced by the weight H_3. The weights F_1 and F_2 are to take up the slack in ropes E_2 and E_1 respectively.



DETAILS AND ARRANGEMENT OF SYSTEM FOR CONTROL OF STEP-BEARING PUMPS

A little experimenting with the pump running and the accumulator up determines the proper adjustment of the rope around the drum *A*.

Assume that the throttles and pumps correspond as follows: A_1 to pump No. 1; A_2 to pump No. 2, and A_3 to pump No. 3; also, that pump No. 1 is running and pumps Nos. 2 and 3 are held as auxiliaries.

The method of regulation is as follows: If the accumulator weight *G* drops, the weight H_1 drops with it, pulls on rope E_3 and opens the throttle wider on pump No. 1 and causes the pump to speed up and raise the accumulator and weights to the normal position, thus maintaining a constant pressure. If for any reason pump No. 1 does not keep up the pressure and the accumulator and weights are further lowered, the slack in rope E_2 is taken up and pump No. 2 is started. If both of these pumps fail, or if the pressure is still further lowered for any reason, pump No. 3 is started in the same manner.

When it is desired to run either pump No. 2 or 3 alone and hold the other two pumps as auxiliaries, all that is necessary is to take up the slack in the rope on the pump to be started, open the throttle and adjust the rope on the drum and around pin *I* to the proper running position (which, for convenience, has been determined and marked beforehand) and let the slack in the rope of the pump to be shut down equal that of the rope of the pump just being started.

T. H. PAYNE.

Worcester, Mass.

Boiler Sheet Bagged

A slight distortion was noticed on the fire sheet of a return-tubular boiler, and as the boiler was free of scale and oil, the cause was a mystery. Everybody about the plant agreed that overheating the plate was the cause, but the boiler was never working beyond three-fourths of its capacity.

The boiler is inspected regularly and the distortion is getting larger and deeper. It now has an area of about 1 sq.ft., starting about 6 in. from the front head, and is fully ¼ in. deep. The inspectors, however, seem to be satisfied as to its safety.

I was visiting the plant one Sunday when the engineer was washing out the boiler, and before he closed the front manhole he put in an ordinary water bucketful of boiler compound without first dissolving it in hot water and right in the depression caused by the bag. Since then there has been no mystery about the formation of that bag. The compound does not readily dissolve in cold water and when a fire is started under the boiler, overheating the plate occurs, as the water does not come in contact with the sheet under the compound.

ADOLF RATHMAN.

Chicago, Ill.

Finger Prints

Finger-print evidence shows whether the men around the power plant take an interest in reading the engineering literature that comes to the engine room. A well thumbed file of POWER in the engineer's office should please any manager.

Finger prints on the bright work in the plant is an evidence of carelessness, but when they are on the pages of a trade paper or on catalogs they show that the owner of the fingers is trying to keep uptodate. In other words, for some finger prints it is not necessary to be ashamed.

A. S. MERRILL.

Easton, Penn.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Underfeed Stoking vs. Overburning

Orosco C. Woolson made some statements in his letter under the above title in the Dec. 12 issue which do not "gee" with my observations and experience.

He seems to fear that the method of supplying air exclusively from below the fire is bound to result in incomplete combustion because "whatever the quantity of air admitted through the grate, it would expend itself on the coke only" to form CO and no oxygen would be left to complete the combustion to CO_2 above the fire. His fear might be substantiated if the air were perfectly and rapidly diffused throughout the fuel bed, but such is not the case. With any kind of furnace and any kind of firing, the tendency of the air is to find channels of least resistance through the fire bed and hence when the draft is sufficiently strong, an ample air supply can easily be maintained.

The importance of an intimate mixture of an ample supply of air with the volatilized combustible matter of the fuel is emphasized in one of Mr. Woolson's paragraphs. In what better way could this be accomplished than by forcing the air up through the fire along with the combustible volatile matter? This is what takes place in the underfeed stoker; the air enters the fuel bed at the lower side of the combustion zone along with the gasified hydrocarbons that have been distilled from the green fuel underneath by radiant heat. The air and hydrocarbons pass upward together through the fire, intermingling as they go.

The probable reactions are as follows: The hydrocarbons burn to CO_2 and H_2O and are immediately broken down again to CO and H while passing through the fire zone. In the fire zone there is, then, incandescent solid carbon, CO, H, free O and N. Emerging from the fire zone, the gases cool until the hydrogen burns to H_2O again and the CO to CO_2.

When combustion takes place at ordinary rates, excess air must be supplied or else the diffusion will not be rapid enough for each molecule of oxygen to find and combine with its molecule of CO before the gases cool beyond the combining temperature.

In conclusion, I should like to point out, as proof that underfeed stoking is as efficient as practically any other method of firing, that good results are being obtained with such installations in plants all over the coal-burning sections of the country. To cite just one case, a recent test of a 540-hp. boiler equipped with underfeed stokers in a large power plant in the Middle West indicated a combined efficiency of over 80 per cent.

PHIL LIGHTE.

Woodhaven, N. Y.

What Means the Dome?

A. A. Blanchard, in the Jan. 23 issue, tries to explain the purpose of the dome on a logging engine shown in POWER for Dec. 26, but I do not believe that Mr. Blanchard's explanation is the true one.

If a dome of unusual height were necessary for the little hill climber, why was it necessary to go to the expense of cutting and drilling the boiler sheet when the builder or owner could have easily increased the height or removed the one shown near the cab and riveted a longer one in its place?

If Mr. Blanchard will examine the picture again he will see a heavy flange riveted on the side of the dome near the top. Judging from its appearance, this flange was tapped for a 2-in. pipe at least, which, I think, was for some other purpose than to relieve the boiler of steam when cooling down for repairs.

J. W. DICKSON.

Memphis, Tenn.

Engine Load Not Equalized

In regard to Mr. Gordon's compound-engine diagrams in the issue of Jan. 23, I suggest that he shorten the cutoff in the low-pressure cylinder, thereby giving it a larger share of the total work and decreasing that done by the high-pressure cylinder.

By making the low-pressure cutoff earlier, the receiver pressure is raised and consequently the back pressure in the high-pressure cylinder is increased, decreasing the work done in that cylinder. The adjustment of the low pressure cutoff does not affect the engine's total work, as this depends upon the amount of steam admitted to the high-pressure cylinder and the total number of expansions occurring in the entire engine, both of which factors are constant with constant high-pressure cutoff.

The receiver pressure which gives equal distribution of work between the cylinders, may be determined by the cut-and-try method of taking diagrams for several adjustments of the low-pressure cutoff until one is found which gives diagrams showing equal power.

HENRY E. CHAMBERS, JR.

Buffalo, N. Y.

Setting Valves on Corliss Engine

In the article under the above heading in POWER for Jan. 23, the setting of the safeties is not considered. I think that the proper adjustment of the governor so that the safeties will operate at the right time is much more important than the equalization of the points of cutoff.

When I adjust the governor on a Corliss engine, I first raise the governor to its highest position and block it there. I then adjust the governor rods until the knock-off cams will just prevent the latches from hooking on when the wrist-plate is rocked back and forth. Then, I lower the governor to the running position and block it there. If I find that the points of cutoff are uneven, I shorten up on the end having the longest cutoff. By shortening the longest end, the knock-off cam is still sure to take effect when the governor is in its highest plane.

After thus equalizing the two ends, I lower the governor to its lowest position and adjust the safety cams so that the latches will not hook on with the governor in this position. If these adjustments are properly made, the engine should not overspeed when losing a load or when the governor belt breaks or runs off the pulley.

I once took charge of an engine which apparently was adjusted without thought of the safeties. At the first opportunity, I adjusted the governor so that the safeties would operate. For this I was soon to be thankful. This engine and a waterwheel were connected to a factory load. The belt on the engine was quite loose, although it did not slip, as far I was able to observe.

One day the gate of the waterwheel dropped, due to the rack connected to the gate being worn out. This threw the whole load onto the engine, which also had to drag the wheel. This load was too much for the loose belt, and as I came through the engine-room door I was in time to see the belt slip from the pulley into the pit. This was when I was glad

that I had changed that governor. I could not notice any increase of speed to speak of; the governor simply went up and the engine did not take steam for a few strokes.

LESTER A. FITTS.

West Fitchburg, Mass.

Wanted: Engineer of Pleasant Disposition

Mr. Morton, in the issue of Jan. 23, takes exception to an advertisement in which an engineer of pleasant disposition is asked for. From his remarks it will be inferred that the engineer must be cross or surly who would fight for his rights. If I were an employer and had the misfortune to hire a man to run my plant who was always finding fault and dissatisfied with everything, I should get rid of him as soon as possible.

I have had assistants in steam plants whom nothing could satisfy, and if they were not kicking, they were trying to throw cold water on any new arrangement or plan that we wished to try out. What a contrast there was between these men and those who were trying to make the best of their lot; the former were in a rut of inefficiency while the latter were "making good." I do not mean that a man should try to be contented under bad conditions, but he should seek to improve his position; he cannot gain success with an ugly or combative personality.

We are led to believe that a man with a pleasant disposition will not have the backbone or brains to stand up for his rights. This may be true in some cases, but if he lacks the brains to do that, how long will he last while running a plant?

Mr. Morton also says that such men "do not know their business as engineers; consequently they cannot explain their duties to their employers." It is not necessary that a man should have a surly disposition to prove his worth to his employer or to place him on good terms with those around him.

In our business, engineers who allow an unruly temper to get the best of them are not making a success. Each in his own experience can remember perhaps some chief he had who in time of trouble did not fly into a passion but quietly gave his orders and had everybody working hard to help him out. While I realize that in such times it may be quite the proper thing for a chief to try to "rip things up," I doubt if this method ever benefits the right sort of help.

An engineer need not be a "man-eater" to get his rights; if the firm wishes to be fair, it will listen to him much more patiently than to one who threatens or whines.

G. H. KIMBALL.

East Dedham, Mass.

Engineer's Reference Book

I have been much interested in reading the letters on "Engineer's Reference Book," having started a book of this character some 15 years ago. After carrying it on for about three years, I found that it got too bulky and consumed too much time. I made a practice at first of writing in this book the gist of the matter from various articles for ready reference. But it became a decided nuisance to transcribe the necessary material, and not infrequently I left out a great deal of information which later I wished I had on file. Then I gave up the book and started in along totally different lines.

I divided my material into three general groups: First, a data book solely on costs, in which every quotation I received was placed, with full information regarding the machinery, its cost and the date of the quotation, reducing the figures when advisable to unit costs. Second, a scrap book in which I pasted the clippings of interest from the engineering magazines, carefully indexing this book. Third, a filing system for clippings from engineering papers or magazines which were too large or bulky to be conveniently placed in the scrap book. For the latter there was no separate index; the folders themselves served this purpose, as on the edge of each, where it protruded from the file, was marked the subject in that folder.

While this does not give me a reference book that I can readily carry in my pocket, it is very easy to collect such information as I may need at any time and take it with me, and I can put my most valuable and frequently used information into a small loose-leaf notebook.

The great thing is to obtain information not only on a subject which may be of interest at the moment, but also on all subjects of allied interests, and to keep posted so far as is possible on all engineering subjects.

An engineer in a shoe factory may be looking for all the information he can obtain regarding the general operation of shoe-factory plants, and then he may be transferred to some other character of plant. If his information does not cover the character of plant to which he is transferred, he will be more or less at sea, except so far as the engine room is concerned.

If, however, he has kept posted on not only the operating features of the first plant, but also on the costs of the apparatus, including not only the engines, pumps, boilers, piping, etc., but also the shafting, pulleys, belts, oil, hangers, cost of operating the various machines, etc., in the shoe factory, and the cost of operation of the various machines in other types of factories, he will be of considerable value outside of just the power plant. Such information will enable him to prove his value and step upward.

There is always a good deal of information to be obtained on methods of keeping track of the operating features of plants as well as determining the fixed charges; and if a man proposes to be of service, he should know the fixed charges, as these have a material bearing on the cost of power. The more he knows, the more valuable he is to his employer if he uses tact in demonstrating his knowledge.

HENRY D. JACKSON.

Boston, Mass.

Fuel Economy and CO_2 Recorders

I read with interest A. D. Williams' discussion on "Fuel Economy and CO_2 Recorders" in the Jan. 23 issue, in which he attacks the accuracy of the intermittent type of recorder.

I will not attempt to state which of the three types of recorders mentioned is the best, but I would take exception to his reasons why the intermittent type is objectionable. One of his reasons is that the recorder takes samples "at intervals of from 5 to 10 min. or more" and the serious disadvantage arising from this is that the firemen can cheat; that is, he "can approximate the time interval and lag of the apparatus and so arrange his work that the admission of surplus air to his furnace occurs during the periods when samples are not being taken."

If this were the case, it would be a serious objection; but with the uptodate type of intermittent recorder—which is almost continuous and may be handled by anyone of ordinary intelligence—there is no excuse for the time interval between the recording of two consecutive samples exceeding 2½ min. The time is really only about 1½ min., as the analyzed sample is drawn for a period of about 1 min. from the continuous stream of gas flowing from the gas passage to the recorder.

There is no way for the firemen to know when a certain volume of flue gas is in the sampling pipes, and if he did, he would be clever if he could bring about changes in the fires which would be to his advantage and happen in an interval of 1½ or 2 min. If a fireman who receives a bonus for a high percentage of CO_2 would attempt this he would find the percentage going down instead of up, especially if one recorder were connected to six or more boilers.

Another disadvantage of the intermittent type which Mr. Williams states is that the "interval has to be sufficiently long to permit the potassium-hydrate solution to absorb the carbon dioxide, and as a fresh solution acts more rapidly than one nearly saturated with gas, the time must be fixed to suit the slowest-

acting solution." I will admit that in some of the unsuccessful makes where the CO_2 must be absorbed by the gas coming in contact with the surface of the potassium hydrate, this is true; but where the gas is made to bubble through it there are no grounds for this objection.

CHARLES M. ROGERS.

Detroit, Mich.

Central Station vs. Isolated Plant

The last third of a century has witnessed a marvelous development in the realm of power generation and transmission, and unavoidably in the connection there has been a great readjustment of conditions under which men are employed. As a result, some positions have been abolished, and it is but human that the men displaced should feel unkindly toward the direct cause of their misfortune. According to some criticisms, it would appear that the central station is a monster going about devouring engineers' jobs, and is so insatiable that it must get them regardless of the means required. Is it any wonder, then, that engineers have taken up arms against this monster? It is doubtless true that the central station, in finding its legitimate field, sometimes oversteps the boundaries. In such cases the pen is the proper weapon for driving it back.

Many of the articles have, probably unintentionally, paid the central stations a decided compliment and offer a ray of hope for the displaced employee. The compliment is the reference to the trained solicitors which the central stations are credited with employing, and the ray of hope is the thought that a new field has been opened for men with engineering ability. These trained solicitors must necessarily have a knowledge of engineering, and while not all engineers can become central-station solicitors when their positions are abolished, they have the consolation that the solicitor who took their jobs away is not himself an engineer seeking the same jobs.

When central-station solicitors use misleading arguments and misrepresent matters in order to attain their ends, their methods should be condemned in no uncertain words, but when the facts are on their side and the user of power would clearly be the gainer by the installation of central-station service, the engineer should humbly submit.

Is it not true that with the development of central stations the field for steam engineers has been enlarged, and that a larger percentage of the working population is today employed in that work than ever before? Today every town of any size has an electric-light plant, and in many instances the engineers employed are in addition to the number that would be working in those towns were there no lighting plants.

Perhaps electric-railway power plants are not exactly included among the central stations referred to, but their development has been a part of that of the electrical line and they have created many places for steam engineers that would not have otherwise existed. In but very few instances have the electric railways displaced any other employers of engineers; instead, they have opened up an entirely new field not only for the employment of engineers but also for many other workers.

In reading these articles the writer has frequently asked himself, are the engineers more fair and conscientious in this matter than those they condemn? When the question of installing central-station service comes up, do the engineers calmly consider the matter and set about determining whether it will be advantageous to put in the service, and if it will clearly be to their employers' interests? Do they honestly admit it, or do they use every argument at their command to induce their employers to retain the steam plant to their disadvantage? Every plant is a problem by itself and careful figuring is required to determine whether it should be abolished.

Engineers should endeavor to be as fair as they wish others to be and be thankful for the fact that undoubtedly there are more opportunities for good engineers in this country today than ever before, even though in their immediate vicinity some positions have been closed. The writer does not wish to be understood as accusing engineers of lacking integrity, but his acquaintance with both engineers and central-station men leads him to believe that the one is as likely to err as the other, and that both professions rank as high morally as most others.

G. E. MILES.

La Jara, Colo.

Smoke Prevention with Steam Jets

In the Jan. 16 issue, J. A. Switzer's article under this title unquestionably deserves the attention of the operating engineer. Near the bottom of page 76 in the first column, the draft is given as follows: Draft gage near stack, inches of water, 0.32, 0.29; and near the bottom of page 78, draft at breeching, inches of water, 0.17, 0.19.

These two readings for each plant represent all the draft information for the four tests. Draft information is very important and no report pertaining to a furnace can be of value without it. Engineers of a few years ago omitted it because they did not know much about it. The statement of draft as given does not convey any real significance at all and the reader is no better off for its being there.

To be of value, draft must be read in the stack, in the breeching at each side of various turns, at both the stack and the boiler sides of the damper, at every pass, whether horizontally or vertically baffled, in the combustion chamber, over the fire and in the ashpit, as shown in the sketch.

The meager information given about the draft is synonymous with stating that there was 10 lb. pressure near the point of cutoff. This certainly would not convey any idea about the actual performance of the engine.

Knowing the height of stack, the draft reading at the stack indicates whether it is over or underloaded or of just the right proportion. If the stack shows very much less draft than it should, it must be overloaded (excessive friction) or very much underloaded (lacking sufficient temperature), and this can be determined by knowing the load.

Readings at the breeching convey the idea of its design as to size, insulation and restriction. Damper readings are necessary to know if the damper is of the desired size to accommodate the gases, and readings at different passes are necessary to know if there is not undue restriction. The reading over the fire shows whether useful work is being done, and all combined will show whether too much air or too little is being admitted. High reading over the fire and no drop or a small drop through the boiler indicates practically static draft at the fire and little or no work is being accomplished. A small drop through the fire and a large drop through the boiler and breeching will indicate large negative work and consequently a large surplus of air.

Where the stack is as close as possible to the boilers, a draft in the breeching of 0.3 or 0.4 in. is very small and there must be something very extraordinary at the Knoxville plants, as both stacks appear from the photograph to be more than 100 ft. high. Usually about 50 per cent. of the breeching draft should be available over the fire. In this case the very most that can be expected for the Knoxville Ry. & Light Co. plant is about 50 per cent. of 0.32 or 0.16 in. This is a very poor draft indeed. In the second test there is 0.29 in. in the breeching and possibly 0.145 in. over the fire.

From practice it can be stated that to burn coal economically at least 0.01 in. of pressure difference must be provided over the fire for every pound of coal burned per square foot of grate surface per hour; that is, if 15 lb. is to be burned per hour per square foot, the draft over the fire must be at least 0.15 in. Hence it will be seen that 0.16 in. will not burn very much coal with economy. This

holds good between 18 and 25 lb. per square foot per hour.

The second very important item missing is the rate of combustion; that is, the number of pounds of coal burned per hour per square foot of grate surface. But knowing the coal burned, the time and the average number of square feet of grate, it can be found.

On the test without steam jets at the Knoxville railway plant there were 270 sq.ft. of grate surface, on which, in 11 hours, was burned 74,213 lb. of coal. This makes the rate of combustion

$$\frac{74,213}{11 \times 270} = 25 \text{ lb. } (nearly)$$

In the second case, 56,700 lb. were consumed during 11 hours on 262.5 sq.ft. of grate surface, making the rate of combustion

$$\frac{56,700}{11 \times 262.5} = 19.64 \text{ lb.}$$

At the Knoxville Cotton Mills, during the test without steam jets, 20,313 lb. were consumed during the nine-hour test on 175.5 sq.ft. of grate surface, making the rate of combustion

$$\frac{20,313}{9 \times 175.5} = 12.86 \text{ lb.}$$

With steam jets working during the nine-hour test, 18,188 lb. were consumed on 131.5 sq.ft. of grate surface, making the rate of combustion

$$\frac{18,188}{9 \times 131.5} = 15.4 \text{ lb.}$$

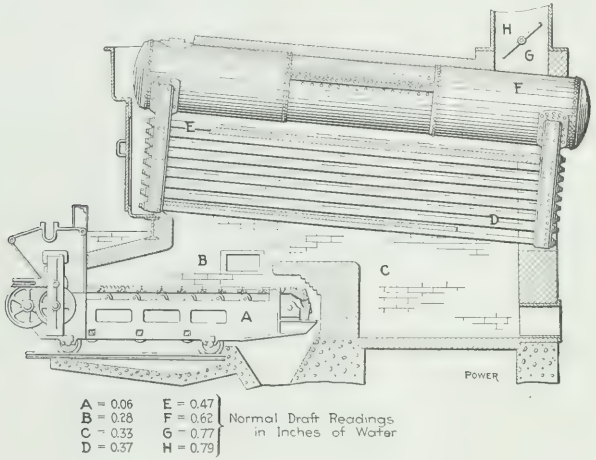
Draft in the breeching at the cotton mills, as given in the first instance was 0.17 in., of which possibly 50 per cent. over the fire would be 0.085 in., and in the second case, 0.19 in., of which 50 per cent. over the fire would be 0.095 in.

As stated before, the rate of combustion depends on the draft, and for each pound burned per hour per square foot of grate is required at least 0.01 in. Having this in mind, examine the data obtained:

KNOXVILLE RAILWAY & LIGHT CO.

1	No steam jets, rate of combustion, lb.	25
	Possible draft over the fire, in.	0.16
	Desirable minimum draft, in.	0.25
	Difference between desired and actual draft, in.	0.09
	Shortage in percentage, per cent.	0.56
2	Steam jets, rate of combustion, lb.	19.64
	Possible draft over fire, in.	0.145
	Desirable minimum draft (0.01 × 19.64), in.	0.196
	Difference between desired and actual draft, in.	0.051
	Shortage in percentage, per cent.	45

From this it can be seen that the trial with steam jets was conducted with 45 per cent. lack of draft, and without the steam jets it was 56 per cent., or, draft conditions were better with the steam jets by 11 per cent. As will be explained further, steam jets have nothing to do with draft itself.



POINTS AT WHICH DRAFT READINGS SHOULD BE TAKEN

Now examine the second case.

KNOXVILLE COTTON MILLS

1	Trial without steam jets, rate of combustion, lb.	12.86
	Possible draft over the fire (50 per cent. of that at the breeching), in.	0.085
	Desirable minimum draft over the fire, in.	0.1286
	Digerence, lb.	0.0436
	Lack of draft in percentage, per cent.	50
2	Trial with steam jets, rate of combustion, lb.	15.4
	Possible draft over fire, in.	0.095
	Desirable minimum draft, in.	0.154
	Difference, in.	0.059
	Lack of draft in percentage, per cent.	60

From this it appears that in the case of the Knoxville Ry. & Light Co., the firemen were overcrowding the fires; that is, the lack of economy was due to heavy firing and lack of air. In the second case, the lack of economy was due to too much air, as it is well known that 12 lb. per square foot of grate per hour will not keep the grates properly covered, and this is shown by less breeching draft, indicating negative work (excess air). With steam jets, when the rate of combustion increased to 15 lb. the breeching draft was raised to 0.19 in., showing a smaller surplus of air than during the first test.

A rate of combustion less than 18 lb. per square foot per hour is always conducive to a very large amount of gas per pound of coal and cannot be recommended for the reason that sufficient furnace temperature cannot be obtained, and the gases run as high as 35 lb. or more per pound of coal. Steam from a steam jet with a nozzle opening of $\frac{1}{8}$ or $\frac{3}{16}$ in. expands to atmospheric pressure within 5 ft. from the nozzle and the hand can be held 6 ft. from the nozzle without any discomfort. From this it is apparent that steam jets cannot blow any soot from the tubes, but they prevent the formation of soot by assisting in obtaining a better mixture in the furnace. That is all steam jets are good for; whether they pay for themselves in doing this is rather doubtful, but there is no doubt that they do not add to economy.

Steam jets do not affect the draft and their action cannot be detected at any other point with a draft gage except over the fire, and then only when the fires are too heavy or the point where the draft is taken is in the immediate neighborhood of the jet discharge.

So far as an economy of 10 per cent. of fuel goes, the steam-jet man must be given credit for doing the right thing at the right place in these two cases, obtaining the same result by different changes in the two furnaces. In one case the rate of combustion was decreased, avoiding the static draft, and in the second case the rate of combustion was increased, so as to have less air holes and a better temperature, and the credit for the whole change is given to the steam jets.

HENRY MISOSTOW.

Chicago, Ill.

Brick for Boiler Walls

Referring to Mr. Scheiderer's letter in the issue of Jan. 9, we have a boiler in our plant with an outside wall built of hollow cement blocks. They have proved satisfactory as an outside wall, giving a neat appearance to the boiler room, which is the only benefit I can see in their use. These hollow cement blocks will stand a good bit of heat, although they will not do for firebox work.

LAMOTT R. LEONARD.

Uniontown, Penn.

What we want at times is an alarm clock that will not only wake us up, but will make us feel like getting up, says *Printing Trade News*.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Steam Pump Valves

What is meant by a pump with steam-thrown valves?

D. O. L.

In direct-acting steam pumps a rotary motion is not developed by means of which an eccentric can be made to operate the valve. It is therefore necessary to reverse the piston by an impulse derived from itself at the end of each stroke. This cannot be effected in an ordinary single-cylinder pump with a single valve, as the valve would be moved only to the center of its motion and then the pump would stop. To overcome this difficulty a small plunger or piston is provided to move the main valve of the pump. In some pumps a small auxiliary slide valve actuated by a piston rod through levers, operates the valve piston. This piston, carrying with it the main valve, is thrown over by the steam and the pump is reversed.

In other pumps, the valve piston or plunger is operated by the main piston striking valves or tappets located at each end of the cylinder. The tappets open a port leading from the ends of the valve plunger directly to the exhaust, thus relieving the pressure at that end of the valve piston. The expansion of the steam at the opposite end of the piston, causes it and the valve to change its position, and reverses the direction of travel of the main piston.

Discharge of Water from a Pipe

What is the formula for figuring how much water a given size pipe will discharge per minute under a given pressure?

A. D. P.

For a pipe running full the formula is

$$Velocity = c\sqrt{\frac{diameter}{4} \times slope}$$

When the velocity is in feet per second, the slope is the head (or pressure expressed as a head in feet) divided by the length of the pipe in a straight line from end to end; c is a constant varying with the character and diameter of the pipe, and the slope, from 69.5 for 6-in. rough pipe to 171.6 for a 20-in. smooth pipe. The tables for the value of c can be found in any engineers' reference book. The amount of discharge in cubic feet per second can be found by multiplying the velocity determined above by the area of the pipe in square feet.

Fusible Plug in a B. & W. Boiler

Where should a fusible plug be placed in a Babcock & Wilcox boiler?

H. S.

It should be placed in the upper drum, not less than 6 in. above the bottom, and over the first pass of the product of combustion; it should project in the sheet not less than 1 in. This rule was formulated by the Massachusetts Board of Boiler Rules.

Size of Wire for Induction Motors

What size wire would be required for secondary street mains to supply two 5-hp. and one 1-hp., 220-volt, 60-cycle three-phase induction motors located 235 ft. from the transformer?

W. C. M.

No. 8 B. & S. weather-proof wire could be used and come within the insurance rules, but the energy loss would be nearly 5 per cent. No. 6 has an energy loss slightly under 3 per cent. No. 4 would be the best size, as the energy loss would be only 1¾ per cent. and the voltage drop about 2 per cent. at full load.

Transformer Connections

Why has a transformer six terminals to its coils when there are only two windings?

J. J. C.

The secondary winding is divided into two distinct coils, which may be connected in series or in parallel, whereas the two primary coils are connected permanently in series. When connected in series the secondary coils give twice as great a voltage as when connected in parallel. The two ends of each secondary coil are run to the outside of the case to be connected as desired.

Saturated and Superheated Steam

When does steam cease to be saturated and begin to be superheated?

A. P. H.

This occurs as soon as the temperature of the steam is raised above that which is produced when it is evaporated. For example, the temperature of steam evaporated under a pressure of 130 lb. (absolute) per square inch is 347.4 deg. F.; if it be heated above that temperature, it is said to be "superheated."

Critical Data

What is meant by critical data of gases?

P. McQ.

There appears to exist for each gas a temperature above which it cannot be liquefied, no matter what amount of pressure is used. This is called the critical temperature. Below this temperature all gases or vapors may be liquefied if sufficient pressure is used. The pressure which causes liquefaction of a gas at or as near below the critical temperature as possible is called the critical pressure. The critical volume of a gas is its volume at a critical point, measured with its volume at the freezing point, under the pressure of an atmosphere as a unit. The critical temperature, pressure, and volume are frequently referred to as critical data. For example, the critical data of carbon dioxide are: critical pressure, 1131.9 lb.; critical temperature, 87.8 deg. F.; critical volume, 0.0066.

Repairing Commutators

What material is best to fill the holes between the commutator segments when the mica has become dislodged?

A. V. C.

Prepare a mixture of powdered mica and thick shellac; set it on fire to burn off the alcohol, taking care to prevent the shellac from charring. When burned sufficiently, extinguish the flame by covering the receptacle with a piece of tin. Apply the paste as quickly as possible, pressing it into the cavity with a heated screwdriver or knife.

Short Circuiting a Shunt Wound Generator

If a shunt-wound generator is short-circuited at the brushes, which would burn out, the armature or the field coils? In what case would the field coils be burned?

A. L. P.

If anything burned, it would be the armature coils, but with some machines the external characteristic is such that short-circuiting kills the field before the armature is damaged. The shunt-field winding could not be damaged by short-circuiting at the brushes under any conditions.

Reminiscences of an Engineer

By Schuyler G. Hooper

Wherein are related some of the things an engineer should not do, and some practices which may assist others who know no remedy for similar troubles.

I had been chief engineer and fireman for six months in a laundry, had studied some and thought I could run anything moved by steam. One Sunday morning an ad appeared in the local paper which read:

WANTED—Engineer to take care of Corliss engine; must be sober and industrious; salary, $75 per month.

I applied for and secured the job. The plant consisted of two 200-hp. Stirling boilers, one 16x42-in. Corliss engine, one 60-kw. dynamo, two 4-ft. Sturtevant fans, a small air compressor and several minor appliances. The engine was belted to a countershaft which in turn was belted to the dynamo and fans.

I was to start the plant the next morning, so I hurried away and secured a man to take my place at the laundry; then I took him to the manager and tried to explain things. Well, I received a lecture that I will not forget right away.

When Trouble Began

The next morning at 5 o'clock I was at the new job and started my first Corliss engine. The foreman showed me how to adjust the voltage by turning a handwheel on the front of the switchboard, and several other things which he had seen my predecessor do. The ding of the dashpots was music to my ears and I was proud of myself until about 9 o'clock, when all at once the dashpots quit their music and the engine slowed down. I could not find any hot boxes, and the steam gage which was on the wall showed 125 lb., which was more than sufficient.

I tried to start again, but the engine promptly shut down when the load came on, and I was more than worried. The fireman reported 140 lb. of steam and said that the pressure was rising in spite of the fire-doors being open and all the draft cut off. He said the safety valves had always "popped" at 126 pounds.

The Gage Pipe Freezes

The superintendent, who had been watching me, was getting ready to leave in a hurry when I said that there was something wrong with the gage. It was an extremely cold day and the gage pipe, which ran across the ceiling and then down to the gage, had frozen and the expansion was raising the pressure. When the pipe was thawed there was 45 lb. pressure. In 15 min. things were going all right once more and I had the gage moved to the front of the boiler where it belonged. The engine had been shut down for an hour, when the trouble should have been located in five minutes.

Hot Bearings

At about 10 o'clock I made a round and examined all the bearings, and when I placed my hand on the main bearing I scorched my fingers. It took me the next two hours and enough cylinder oil to last the engine a week to get it back to normal.

I had closed the oil cups during the shutdown and I had forgotten to open them when I started again. All this trouble had taken some of the confidence out of me, and I was as tired at noon as though I had worked hard all day.

A Circuit-breaker Incident

Things went quite smoothly that afternoon and the next day, although a circuit-breaker kicked out when I was in front of the board and nearly scared the wits out of me. I threw it back before I knew what I was doing and held it a few moments; then I noticed that the ammeter only registered about half load. While I was wondering what caused the load to fall off, the superintendent came in and told me that, for no apparent reason, about half of the fuses had blown out in the foundry. I did not know why they had blown until I had figured it out in bed that night, and then it was very simple. I had thrown the circuit-breaker back before the starting-levers on the motor-starters had a chance to drop back. This had caused the current to rush into the armatures of the motors without any resistance, and, of course, had blown the fuses. I did not tell the superintendent the cause of that half-hour shutdown in the foundry, but the next time the circuit-breaker went out I let it rest a while before throwing it back.

Whenever I had a little time, I studied and examined things about the place. I found out that the handle on the switchboard which regulated the voltage was fastened to a resistance box which was in series with the shunt field of the dynamo, and regulated the current that passed through it.

The plant was about 400 ft. from the foundry and 500 ft. from the office, and there was no steam in either for heat. Just before I came a tee was placed in the exhaust line and also a back-pressure valve. A 4-in. line was carried from the tee to the office, and several weeks after my arrival the radiators were installed and everything was ready to turn on the steam.

The Superintendent Lends a Hand

One morning I slowly opened the valve on the 4-in. line and then started to put some weight on the back-pressure valve, the arm of which was tied with a rope. While I was hunting for the weight the superintendent, who had come in to see the heat turned on, cut the rope which held the lever to the valve. The engine immediately started to slow down and I rushed for the throttle and had it about half closed when there was an explosion and the room was filled with steam. I finished closing the throttle as fast as I could and then ran outside.

There stood the superintendent, looking a little whiter than usual but not hurt in the least. As soon as the steam permitted, we again entered the engine room and found the cover plate on the front of the heater broken in three pieces. Nothing else appeared to be out of order, but I thought there was something wrong with the back-pressure valve, so I tied it back with the rope, and started up again. Everything was all right except that I had to feed cold water to the boiler, which taught me that a feed-water heater was an economical adjunct to the engine room.

The Steam-fitter "Quits"

That night I took the top off of the back-pressure valve and found that the steam-fitter had placed it on upside down. I should have noticed this, but I had never examined one before, so the company lost by my inexperience. The steam-fitter was given a chance to look for a new position the next day, and I was a little shaky about mine, but nothing happened. The valve was correctly placed and the broken heater repaired; that ended that incident.

Dashpot-plunger Troubles

Several days later I noticed that the dashpot plungers did not pull down as far as they should and the hook would hit them and make a noise, so I promptly oiled them and they worked quite well until the next morning, when they were more sluggish than ever. I again oiled them with engine oil, but they did not operate properly. I worried along with them that day, but I hated the thought of starting the next morning as they were always much worse on cold mornings.

That night I purchased my first copy of POWER from a newsstand and while

reading over some of the other fellows' troubles and remedies, I ran across one which fitted my case exactly. It was this: "Never use oil on the inside of the dashpot which has a leather cup on the plunger, as it will gum the leather, cause the plunger to stick and eventually entirely ruin the cup. Use, instead, a little kerosene once in a while, and no trouble will be experienced." The kerosene did the work next morning and POWER received a year's subscription by mail.

All of the lifting in the foundry and machine shop was done with air furnished by the compressor in the engine room. One day a salesman came in with the superintendent and proposed to furnish us all the air we wanted for nothing; that is, without any increase in the fuel bill. He proposed to place a cylinder back of the engine cylinder and carry the tail-rod right through to operate it. He told me the engine had considerable compression, and that he would eliminate it and catch the heavy moving parts with the compressed air. At that time I hardly knew if compression was a contagious disease.

His First Indicator Diagram

The salesman then proceeded to take some indicator diagrams (the first I had ever seen taken) and explained things so clearly to me that I asked the superintendent to let him put in his compressor. He soon had the compressor in; it worked fine and cut the fuel bill a little. However, there was one trouble which I could not overcome; that is, the engine would pound whenever the compressor suction valves were held open by the governor, due to the pressure rising too high in the air receiver. This, of course, was due to lack of compression and a small amount of lost motion in the different bearings.

A Two-day Shutdown

The two 4-ft. fans used were located in the foundry and were run by motors. These motors were too small, and one day a motor burned out an armature, causing a partial shutdown for a couple of days. A consulting engineer was called in and he advised moving the fans to the engine room and driving them from a countershaft. He was asked if the friction in the pipes, when the air passed through, would not make them take more power, but he explained that they would take less power, and he proved his argument by closing a damper in the discharge pipe of one of the fans; the ammeter immediately showed a great falling off in current.

The fans were moved, and when they were started in their new position it was found that while they ran at the same speed as before, they did not deliver as much air to the foundry, so larger pulleys were bought and the fans speeded up until they did deliver the air. The expert went his way. When I tried to explain to the superintendent that the fans were taking more power than before, he said that I did not know what I was talking about, so I had to let it drop.

An Operating Lesson

One more thing happened at this place which taught me more about electricity than any other thing, and this was that as the plant was on the bank of the river the river once rose until the plant was under 12 ft. of water for two weeks. Of course, the dynamo and all the motors were caught and an expert was called to put them back in the proper condition. I supposed he would build a box over the machine and dry them out with steam coil or charcoal fire, but he surprised me by first taking a hose and washing out all the loose mud, and then wiping the machines as dry as possible. After that he started the dynamo with the shunt fields disconnected and the brushes off and let it run until the mud and water were thrown out. Again the machine was wiped dry and the fields connected, the brushes put on and the machine started, but the voltage was not allowed to rise above four or five volts and the main cables were connected.

I had taken it all in and had asked enough questions to fill a book. The expert was very kind in explaining everything to me. He said the reason he used current to do the drying was because it dried from the inside out and not from the outside in; also, that the hot air from the armature assisted greatly in drying the fields. The voltage punctures the insulation and for this reason it was kept low while the load or amperage was kept high to get the heat.

A Question

When he went away, he left a question with me which lasted some time. Here it is in two parts:

How much current does an ordinary 110-volt, 16-cp. light consume? Of course, I said 65 watts, in a hurry. If that is the case and the positive wire is carried to a building and supplies, say, 400 of these lamps, why should it be necessary to bring back a negative wire of the same size to the dynamo? In other words, why does the return wire on any circuit have to be the same size as the positive wire? I did not know, but told him I would find out and write him.

My books did not seem to give me much light and Ohm's law confused me, so I hunted up a couple of practical wiremen and they looked rather startled when I asked them; they told me that it was a custom. I did not believe this, so I studied all the harder and finally wrote my expert friend like this:

"Electricity is not consumed by lamps, motors or any other device, and every ampere which leaves the dynamo goes back to it. This can be proved by simply connecting the ammeter in either side. Lamps or motors are simply reducing valves which cut the pressure of the current, and this current in passing through the lamp causes the filament to heat and make light, and in passing through the motor it causes it to turn."

A few days later I received a reply saying that I was right. I do not believe he knew whether I was or not.

Why American Workers Excel

Sir Hiram Maxim said recently that he had been in England a great number of years and had been associated with firms that employ many thousands of men. It was his experience that there is never any dearth of men for positions where the salary is about 30 shillings a week, but when a man is wanted for a job requiring care and intelligence, it is hard to find them at £5 per week.

In Canada and in the United States there is a totally different state of affairs. From 1877 to 1880 he had charge of electrical work where a considerable number of young men were employed, and today nearly every one of them is in a high position.

At a works in Providence, R. I., where the very best mechanical work is produced, young men were found studying algebra and geometry while the lathe was taking a cut. In England the penny dreadful takes the place of scientific books.

While he was managing director at Erith & Crayford, Sir Hiram had a good opportunity of studying the character of the men. They were all more or less interested in cricket and in football, and it appeared that every one of them was deeply interested in horse racing. Not only this, but much of their money was spent for tobacco and drink. While the American boy is studying his algebra, the English boy is smoking his pipe.

New Type of Engine for the Burlington

The Chicago, Burlington & Quincy system has ordered five engines that are expected to handle 60,000-ton freight trains over any ordinary grade on its roads. The new engines will be equipped with automatic stokers and either slack or crushed coal will be the fuel used.

If these engines prove satisfactory, a large number will be ordered for the Galesburg division in the coal fields and for general freight traffic. They will be put in service next fall.

Good Record of English Municipal Plant

A recent issue of the *Electrician* contains a report of the power-production costs and the business done during the past year by the Manchester Corporation, a municipally owned power company which supplies light and power to the residents of Manchester, England, and also supplies the city with street lighting. By way of comparison, the figures showing the power costs for the preceding year (1909-10) are given, and indicate a decided gain in economy during the year 1910-11.

The electricity is furnished by two stations having a combined capacity of 47,300 kw. The maximum load carried at any time during the year was 37,520 kw. and the yearly load factor based upon this maximum load was 25.35 per cent.

The system represents a total capital investment of about $13,300,000 distributed as follows:

	Amount	Per Kilowatt Installed
Land and buildings	$1,895,000	$40.00
Equipment	3,500,000	74.00
Railway	394,000	8.32
Water supply	31,400	0.66
Distributing station	1,805,000	38.20
Mains	4,770,000	101.00
Meters	306,500	6.48
Motors	182,500	3.85
Electrical instruments	10,950	0.23
Cable stores, etc	148,500	3.12
Other property	249,000	5.28
Street lighting	2,795	0.06
Total	$13,295,645	$280.00

COST OF PRODUCTION

	Per Kw.-Hr. 1910-11	Per Kw.-Hr. 1909-10
GENERATING COSTS:	Cents	Cents
Coal	0.403	0.425
Oil, waste and water	0.044	0.044
Wages	0.103	0.122
Repairs and maintenance	0.080	0.103
Total	0.630	0.694
DISTRIBUTION COSTS		
Wages	0.080	0.103
Repairs and maintenance	0.080	0.103
Miscellaneous	0.023	0.020
Total	0.183	0.226
MANAGEMENT COSTS:		
Salaries	0.061	0.061
General charges		0.020
Special and miscellaneous charges	0.020	
Total	0.081	0.081
Rents, taxes, etc	0.203	0.244
Total costs (excluding capital charges)	1.097	1.245
CAPITAL CHARGES		
Interest	0.406	0.467
Sinking fund	0.568	0.609
	0.974	1.075
Total costs (including capital charges)	2.071	2.320

The revenue for the past two years was as given in the table following:

	Amount 1910-11	Per Kw.-Hr. 1910-11 Cents	Per Kw.-Hr. 1909-10 Cents
Sale of current	$1,930,000	2.32	2.18
Rental of meters	2,350		
Rental of motors	20,640	0.04	0.05
Miscellaneous	8,100		0.03
Total	$1,965,000	2.36	2.56
Balance above expenditures	239,500	0.289	0.24

Of this balance, $105,500 was paid into the renewals account (a supplementary provision with respect to assets having shorter estimated periods of life than the periods of statutory redemption of debt as calculated for the current year). The distribution loss was figured as 20.15 per cent.

Little's Positive Feed Lubrication Attachment

This device is designed to provide a means whereby any ordinary steam lubricator can be transformed into a positive-feed lubricator. The pump is attached to the ordinary lubricator by shutting off the pressure from the lubricator, removing the plug *A* and loosening the packing nuts *B B*, taking out the glass tube and inserting in its place the metal tube *C* so that the outlets *D* and *E* point in the direction indicated; the packing nuts *B B* are then tightened again.

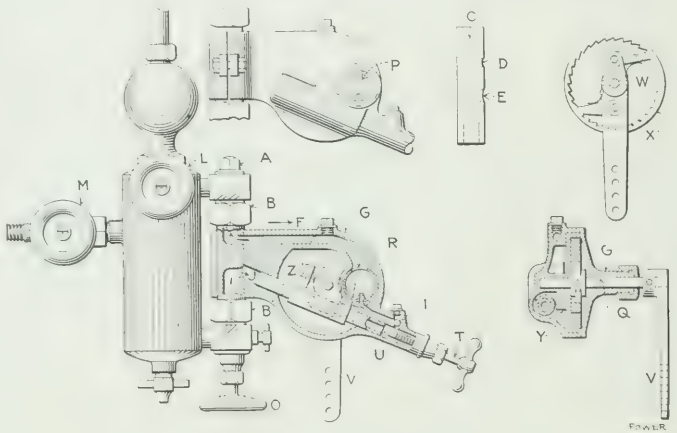
The main body *G* is then placed in position so that the inlet and outlet openings come together, thus forming the passages shown. A clamp around the tube *C* holds the body of the pump in place by means of two bolts. The lubricators can then be refilled in the usual way, keeping the valves *L*, *M* and *O* closed.

The sight-feed glass *P* and passage *R* are full right up to the outlet below the plug *A*. The swinging arm *V* is connected by a small rod and connections to the valve gear. The variation in the number of drops per minute is made by changing the end of the rod from one hole to another. The size of the drops is regulated by screwing the stem *T* in or out, thus increasing or decreasing the amount of oil that is confined in the annular space *U*.

In operation the valve *M* is opened full, and valve *L* is opened just enough to keep the lubricator supplied with water so as to cause the oil to rise in the passage *J* after the valve *O* is opened.

As the arm *V* is moved back and forth it transmits its motion through shaft *Q* and pawl *W* to the internal-toothed ratchet wheel *X*, which carries a cam *Y*. The ratchet wheel and cam are in one piece and turn free upon the shaft *Q* as the cam *Y* revolves between the two yokes *Z*, which are secured to the plunger and force it back and forth in its cylinder. When the plunger is moving in the direction of the inlet *J*, oil rises in the intake and flows in the direction indicated by the arrow and passes through the center of the plunger into the lower cylinder *U*.

When the plunger makes its return stroke, it moves forward until it meets the adjustable stem *T*, whereupon it forces the oil that is confined in the space *U* up past the ball check valve *I*, thence through the passage connecting with the nipple showing in the sight glass, then passes into the top passage, over into the steam pipe leading to the steam chest of the pump or engine.



DETAILS OF POSITIVE-FEED LUBRICATOR

This device is the invention of George J. Little, 83 Lincoln street, Passaic, N. J.

CORRECTION: On pages 178 and 179 of the Feb. 6 issue, in the article, "Various Types of Steam Meters," formulas (3) and (4) should read, respectively:

$$V = K\sqrt{h \times \frac{dw}{ds}}$$

and

$$V = K\sqrt{h \times \frac{dm}{ds}}$$

Laundry Boiler Exploded

By J. C. Callery

On Jan. 2, the boiler of the Imperial Laundry, Hamilton, Ohio, failed at the crown sheet, causing a property loss of $50,000. Fortunately none was killed.

The boiler was of the locomotive type, having a 36-in. shell and thirty-eight 3-in. tubes, each 7 ft. 6 in. long. The shell was made of ¼-in. sheets. The crown sheet was stayed by threaded ⅞-in. stay-bolts, spaced 5x6 in. apart. The safety valve was 2½ in. in diameter.

Nearly all the stay-bolt heads in the crown sheet, as well as on the sides of the furnace, were wasted away. The boiler had just been cleaned of scale, some of which was ¾ in. thick.

It is reported that the boiler was leaking badly around the stay-bolts and tubes and that it required considerable effort to keep the water at a proper height, but the crown sheet does not show any signs of having been burned. One stay-bolt tore out of the crown sheet, the rest, 21 in all, following immediately. Unfortunately the wreckers had removed the safety valve before an opportunity was had of examining it, but a pressure of 40 lb. per square inch was carried at the time of the accident, it is said.

Provisions had been made for a fusible plug in the crown sheet, but this had been replaced by a solid pipe plug years ago. The boiler was over 30 years old.

The building took fire, which spread so rapidly that the employees were saved with difficulty, the building being a total loss.

Boiler Explosion at Knoxville

A boiler in the plant of the Royal Marble Co., Knoxville, Tenn., exploded at 10 o'clock a.m., on Feb. 5, instantly killing two men and injuring three others. The boiler and boiler room were completely demolished. The cause of the explosion is not known.

Locomotive Boiler Explodes

By the explosion of the boiler of a heavy freight engine on the New York, New Haven & Hartford R.R. at New Haven, Conn., on Feb. 6, the engineer and the fireman were badly injured.

Smoke Abatement Movement Censured

In his address before the Electro-Metallurgical Society of Sheffield, England, Prof. J. O. Arnold took occasion to censure the smoke-abatement movement and to point out that without smoke steel is impossible.

So far as health is concerned, he said, the most mischief is caused by the household smoke, yet it is usually ignored by the smoke inspectors.

Prof. Arnold asserted that in steel metallurgy, smoke is absolutely necessary. Any operation that removes the carbon will produce poor steel. If a smokeless flame is used all the carbon is burnt out and the surface of the steel is made rotten. It is realized by many that smoke is essential to the manufacture of good steel and metallurgical furnaces are exempted, but the question of mixed stacks is continually coming up to the annoyance of manufacturers.

Cylinder Head Blows Off

On Jan. 31, at the Potter Oilcloth Works, Second St. and Erie Ave., Philadelphia, Penn., the cylinder head of the engine blew off with such force as to send it through the engine-room wall.

The engineer was stunned by the explosion and while lying helpless on the floor was literally boiled to death by the escaping steam. He was alone in the engine room at the time and the accident was not discovered until the broken engine had ceased to work and employees came to investigate the cause for the machinery shutting down.

Colors for Piping

Standard colors for pipe systems have been adopted by the Verein Deutscher Ingenieure, the Association of Miners in the Dortmund district, and the central Unions of German Heating Engineers and of German Revision Engineers. Green is to indicate water; yellow, gas; blue, air; white, steam; black, tar; pink, lyes; pink with a red ring, acid; brown, oils, and gray, vacuum. A black ring or band indicates impurity; a red ring, danger; thus a green pipe with a black ring carries refuse water; a white pipe with a red ring carries superheated steam; a yellow pipe with a brown ring, oil-gas; a yellow pipe with a blue ring, producer gas; with a green ring, water gas, etc. It is not proposed to paint the whole pipe, as this would in many cases be impracticable. What is proposed is to fix a label of sheet metal at suitable spots and intervals, indicating in addition the direction of flow and further particulars.—*Mechanical Engineer.*

Sacramento Valley Power Co. Sold

The Northern California Power Company, Consolidated, on Feb. 1, at San Francisco, bought the Sacramento Valley Power Co. for a consideration said to be $1,000,000. Prominent bankers and capitalists figure in the transaction as directors and owners in both concerns.

The country north from Chico is mainly interested in this merger proposition. The two companies have developed about 27,000 hp. and can readily increase this in excess of 50,000, because of valuable water rights.

The Sacramento Valley Co. was formed about two years ago by a consolidation of several smaller concerns and has been the only competitor of the other company in the northern counties.

The Northern California Power Co. has been in existence for a number of years and is a combination of eight smaller concerns. It supplies electric light and power, gas and water to many northern localities.

It is said the deal has been made in order to give increased light and power facilities to the northern towns at existing rates, many economies being effected by the merger.

Dinner to Charles F. Hart

On Jan. 25, at Vogelsang's, Charles F. Hart, a former vice-president of the National Association of Stationary Engineers, and now residing in London, was given a dinner by his many friends in Chicago.

The "fuel contract"—otherwise the menu—may have had a few operating features that might be objected to by the conservative engineer, but we understand that at no time were the boilers under any severe strain and that the "liquefied rivets" held tight throughout the test. The specifications for "fuel" follow:

FUEL CONTRACT

Martini Cocktail
Gives that Olympic Roll

Olives Celery
Italy and Kalamazoo have nothing on us.

Cream of Tomato
A la Boiler Compound

Tenderloin Steak, Mushroom Sauce
65,000 Tensile Strength Liquefied Rivets

Green Peas Special Baked Potato
No. 3 Mesh Superheated Spuds

Lettuce, Chicory and Tomato Salad
French Dressing
Free-For-All, make your own book on this

Brie Cheese Toasted Wafers
The Tie that Binds

Coffee
Eases the Pain of Oratory

Smoke
Immune from Prosecution

Program of A. B. M. A. Convention

At the American Boiler Manufacturers' Association's twenty-fourth annual convention, to be held in New Orleans, Mar. 12 to 15, the following papers will be presented: "Rivets," D. J. Champion, of the Champion Rivet Co.; "Compressed Air and Its Uses," Thomas Aldcorn, Chicago Pneumatic Tool Co.; "The Manufacture of Charcoal Iron Boiler Tubes," H. A. Beale, Jr., Parkesburg Iron Co.; "Boiler Explosions: Their Causes and Prevention," Francis B. Allen, Hartford Steam Boiler Inspection & Insurance Co.; "The American Boiler Manufacturers' Association as It Is and as It

Should Be," W. H. S. Bateman, sales agent, Champion Rivet Co., Parkesburg Iron Co., Chicago Pneumatic Tool Co.; "Segregation of Steel," Charles L. Huston, Lukens Iron & Steel Co.; "Modern Boiler Shops and How they Should be Equipped," H. C. Meinholtz, Heine Safety Boiler Co.

The question of uniform boiler laws will be taken up.

A ladies' auxiliary is to be formed at the New Orleans convention, and the Boiler Manufacturers and members of the Supply Men's Association are requested to bring their ladies with them. An excellent program of entertainment will be provided for the visiting members and guests.

Supply and Machinery Manufacturers' Convention

The next triple convention of the American Supply and Machinery Manufacturers' Association, the National Supply and Machinery Dealers' Association and the Southern Supply and Machinery Dealers' Association will be held at Norfolk, Va., on May 13 to 15. Convention headquarters will be at the Monticello Hotel, where accommodations for a large proportion of the delegates may be had. Other accommodations have been provided for the overflow in first-class hotels nearby.

New Publications of Bureau of Mines

Bulletin 15. "Investigations of Explosives Used in Coal Mines," Clarence Hall, W. O. Snelling and S. P. Howell, with an introduction by C. E. Munroe, and a chapter on the natural gas used at Pittsburg, by G. A. Burrell. Technical Paper 6. "The Rate of Burning of Fuse as Influenced by Temperature and Pressure," W. O. Snelling and W. C. Cope. Technical Paper 7. "Investigations of Fuse and Miners' Squibs," Clarence Hall and S. P. Howell.

REPRINTS—Bulletin 31. "Incidental Problems in Gas-producer Tests," R. H. Fernald, C. D. Smith, J. K. Clement and H. A. Grine. Reprint of Geological Survey Bulletin 392. Bulletin 32. "Commercial Deductions from Comparisons of Gasoline and Alcohol Tests on Internal-combustion Engines," R. M. Strong. Reprint of Bulletin 392. Bulletin 33. "Comparative Tests of Run-of-mine and Briquetted Coal on the Torpedo Boat 'Biddle,'" W. T. Ray and Henry Kreisinger. Reprint of Bulletin 412.

The bureau has these publications for free distribution, but can give only one copy of the same bulletin to one person. Order by number and title, and apply to the director of the Bureau of Mines, Washington, D. C.

Engineering Books in all Fields

The McGraw-Hill Book Co. announces the completion of arrangements for the sales agency of the technical books of the *Railway Age Gazette, American Engineer* and *Signal Engineer*. This makes the company publishers and distributors of books for the three journals, but it does not affect the publication of the papers themselves in any way. With the addition of these three papers in the railroad field, the company now publishes books for the twelve leading American engineering papers in the fields of civil, mechanical and electrical engineering, electric and steam railroading, machine tools, mining, metallurgy, chemical engineering, etc. The papers now represented are *American Machinist, Engineering News, Electrical World, Railway Age Gazette, Electric Railway Journal*, POWER, *Engineering Record, Engineering and Mining Journal, Coal Age, Metallurgical and Chemical Engineering, American Engineer* and *Signal Engineer*.

NEW PUBLICATION

KONDENSWASSER-ABLIETER (Steam Traps). A Comparison of the Various German, English and American Types. Their Construction, Operation and Maintenance. By Robert Wagner. Published by Hochmeister & Thal, Leipzig, 1911; 424 pages, containing 484 illustrations.

In this work, which is as yet available only in the original German, Mr. Wagner has not attempted to present any new ideas on the subject of steam traps, but has written it to fill a gap which he considered existed in technical literature.

With considerable attention to detail, he reviews the entire field of steam traps in a more or less encyclopedic manner, discussing their purposes, uses and maintenance and the calculation, construction and selection with regard to specific requirements. His study comprises the German, English and American types, which he compares in relation to their construction, effectiveness and maintenance. He points out that a good many mistakes are being made in the application of the steam trap; the book is written therefore from a practical standpoint with a view of aiding practical men in their choice of this apparatus.

The first three chapters are devoted to a general discussion of the phenomena of condensation, the process of the accumulation of water, and the separation of water from the steam. The author then goes on to explain the conditions under which this takes place and the disadvantages, evils and dangers of condensation and its prevention.

A chapter is devoted to the installation and care of steam traps, followed by another on the calculation and construction of traps, thus giving, in a brief way, a theoretical background for the author's fuller treatment of the various types of traps in use. Throughout the rest of the book he discusses various types in detail, with appropriate pictures, drawings, diagrams and tables; he goes into the construction, advantages, disadvantages and peculiar uses to which each type can be put.

The book would be valuable if it accomplished no other purpose than that of bringing together in a single volume all that has been achieved in this particular branch of steam engineering; but in view of the extensive use of steam for various purposes, such as power, heating, etc., in modern industries, the author has supplied a real need in the way of offering a ready-reference book for the user as well as for the constructor of steam traps. The work is written in a clear, concise and popular style which even the layman will find readily understandable.

SOCIETY NOTES

The American Association of Boiler Inspectors will hold its annual dinner at the Broadway Central Hotel, New York, on the evening of Feb. 21.

The New York State Association, N. A. S. E., will hold its seventeenth annual convention in Yonkers on June 14 to 16. The Getty House will be the headquarters and the sessions will be held in the Armory, Waverly St. Plans are laid to have a large manufacturers' and dealers' exhibit.

PERSONAL

W. M. Vreeland, formerly chief engineer of the Celluloid Co., Newark, N. J., has accepted a position as chief engineer in the plant of L. Bamberger & Co., Newark, N. J.

J. M. Tomey, formerly with the Prudential Life Insurance Co., has been appointed chief engineer of the new Central Commercial and Manual Training High School at Newark, N. J.

Howard W. Evans has been engaged by the Best Manufacturing Co., Pittsburg, Penn., and will hereafter supervise its sales, order and engineering departments. Mr. Evans is a specialist in piping materials. He formerly occupied a similar position with the Crane Co., Chicago, Ill.

E. T. Adams, who was in charge of the gas-engine work of the Allis-Chalmers Co. when the great engines for Gary and South Chicago were built, is said to have interested himself in the Grine oil gas producer, described in our issue of Nov. 14, and to have effected improvements which will insure its commercial success. The Wisconsin Engine Co., of Corliss, Wis., of which Mr. Adams is president, is said to have acquired the patent rights and to be arranging for the introduction of the producer upon a large scale.

POWER

Vol. 35 NEW YORK, FEBRUARY 27, 1912 No. 9

You can show the boss that you are worth more money and you can get it, always providing that you actually are worth more. Maybe you may not succeed in getting it from the present boss, but somewhere there is a boss who wants your talent in his service and is willing to pay you what you are worth —again, always providing you have the talent, and use it.

We can hear some skeptics saying, "Aw, this is all nonsense. All employers are alike, they want you to work for the lowest wages regardless of what you are worth."

You are wrong, skeptics, you deceive yourselves. The nib of the whole matter lies in this fact: it is almost a universal human failing to overestimate one's own worth.

If you are receiving $1000 per year and secretly you believe you are worth $2000, and can't get it, you naturally feel that all employers are persecutors and—well, what's the use anyhow!

Now, the thing to do before arriving at such a conclusion is first to prove, honestly, that you are worth the $2000. Prove it to yourself beyond a shadow of a doubt. Pick out a $2000 man and see how you weigh up with him. Are you producing as good results as he? In a crisis, could you bring as much knowledge and experience to bear as he?

Ten chances to one you will find yourself lacking in some respect or other. If so, the thing to do is to build yourself up in those weak spots—make yourself grow to the $2000 size.

Then, the next thing to do is to deliver $2000 worth of service—apply your knowledge, experience and talents so that the results will be worth a full $2000 to your boss. Because he pays you only $1000 is no argument for stopping when you have delivered $1000 worth of service. If you do stop at the $1000 point, how is the boss to know that you are worth twice as much? Do you think he is a clairvoyant and ought to come to you saying, "Although you only deliver $1000 worth of goods I know you are worth more money, and so I will raise your pay, hoping that you will get a hustle on and make good"? No! He is "from Missouri"! You must show him that although he hates to pay you more money, it is to his best interest to do so rather than have you leave to take a position where the pay is what you are worth.

Engineers' wages range all the way from a dollar and a half a day to $10,000 per year and upward. And right here it may be well to repeat that there is plenty of room at the top. The higher you go, the less competition you will have, and hence the easier it will be to collect what your services are worth.

However, wishing will not get you there, nor kicking.

Honest hard work and study pave the way, and upon the quality of this pavement depends the rapidity of your upward travel.

Hebrew Infant Asylum Power Plant

By Warren O. Rogers

A good example of a small, modern isolated power plant.

The equipment consists of air washing and heating apparatus, with automatic control of the hot and cold air supply; also the necessary steam- and power generating units.

When the Hebrew Infant Asylum, of New York City, was opened for occupancy on Feb. 19, 1911, one more isolated plant was put in operation, and, from the character of the equipment, Chief Engineer Culley should have no trouble in producing electrical energy at a figure not approachable by the central station.

The main building has been erected on a plot of ground at Kingsbridge Road and Aqueduct Ave., New York City. It is five stories high, with a basement, and is constructed of red pressed brick with granite trimmings. An isolated and smaller building, used as a hospital, is located at the rear of the main building, the only connection between the two being an underground tunnel, in which steam and water pipes, electric wires, etc., are run.

The institution is provided with a power plant, including engines, boilers, pumps and other apparatus forming a complete power, heating and ventilating equipment for the buildings.

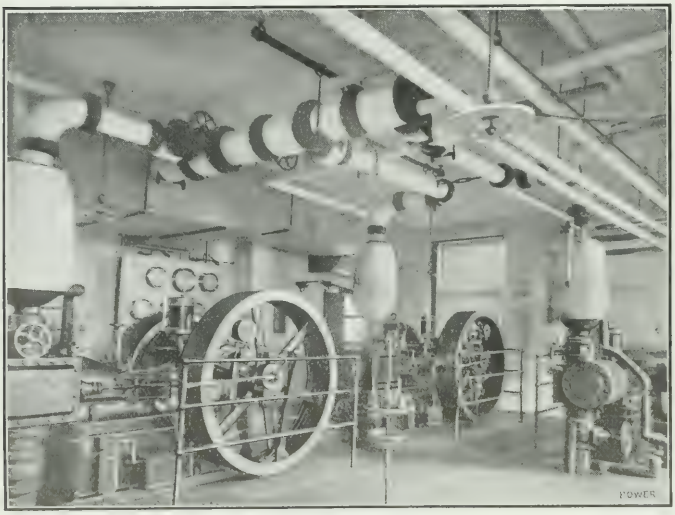


FIG. 1. THE ENGINE ROOM

ENGINE ROOM

The engine room, shown in Fig. 1, is built slightly below the ground level on the Aqueduct Ave. side of the building. In it are two 14x14-in. center-crank engines, each direct-coupled to two 100-kw. and a 75-kw. direct-current generator respectively. The two large engines run at a speed of 250 r.p.m. and the small unit at 275 r.p.m.

At one end of the engine room is a five-panel direct-current switchboard upon which are mounted the necessary switches, voltmeters, ammeters, etc., for the control and distribution of the electrical energy. It is shown in Fig. 2.

BOILER ROOM

Each of the three 150-hp. water-tube boilers is fitted with a 4-in. nickel-plated pop safety valve which is set to blow at 125 lb. pressure per square inch. The furnaces are fitted with improved grates, the bars having a double cutoff movement, and are designed to burn buckwheat coal. The boilers are connected to the vertical smoke flue by means of a rectangular wrought-iron breeching of equal area to the combined damper area and is made of No. 10 gage wrought iron. It is supported from the ceiling of the boiler room by wrought-iron hangers and angle and T-irons.

Each boiler is fitted with a damper, but a separate damper in the smoke flue governs the draft of all boilers and is controlled by a damper regulator.

Coal is delivered to the boiler room in a 1-ton coal car which runs on an industrial track, the rails of which are set flush with the concrete floor.

Under the grating in the boiler room and next to the engine-room wall is a 500-hp. vertical feed-water heater. There are also a boiler tank and grease extractor which permit the water of condensation being used over again as a boiler feed. The boiler blowoff pipes are connected to a steel blowoff tank 3 ft. in diameter by 3 ft. 6 in. long which is placed below the blowoff valve. The drips from all the engines and pumps are connected to this tank. A 3-in. vapor pipe is connected to the tank and is carried to a 4-in. main vapor line which is placed in the vertical smoke flue and discharges to the atmosphere above the roof.

The discharge from the tank is connected to a sump and the contents are pumped by means of a sump pump into the sewer. The blowoff tank is provided with cooling coils constructed of seamless brass pipe. The water in passing through these coils is heated and is then carried to the house and used for a hot-water house supply. All water used in the buildings is filtered by passing through sand and charcoal filters.

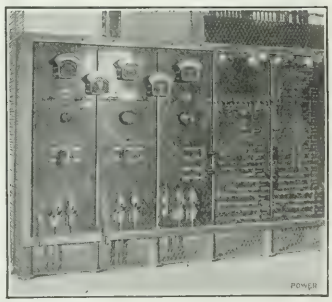


FIG. 2. THE SWITCHBOARD

PUMPS

All pumps are set on a brick foundation, each having a 4-in. bluestone cap. The house-service pump is 6 and 4 by 6 in. in size and is cross-connected with the boiler-feed pump so that it can be used for boiler-supply purposes if necessary. It is controlled by an automatic governor which operates with a float in the tank. There are two 6 and 4 by 6-in. outside-packed boiler-feed pumps. They can also be used for returning the water of condensation from the heating system to the boilers. Fig. 4 shows a section of the pump room.

The underwriter fire pump is 10 and 6 by 12 in. in size and is used entirely for fire protection to the building. It is cross-connected with the house pump.

Piping

Each boiler is connected by a branch outlet to a 12-in. header, as shown in Fig. 3, from which connections are taken for all engines, pumps, air compressors, etc. Valves are placed on the exhaust pipes of all engines, pumps and air compressors, and from these valves connection is made to a 12-in. main-exhaust header, from which a 10-in. branch extends to the feed-water heater. A 12-in. pipe runs through a muffler tank and connecting to a back-pressure valve rises to the roof. The exhaust piping of all the small pumps in the boiler and engine rooms is grouped and connected to a 6-in. outlet on a 10-in. branch pipe running to the heater. Two feed pumps are connected to a 3-in. brass pipe which extends to the top of the boilers in the front and connects with the boilers through a 2-in. brass pipe.

An interesting arrangement of high-pressure piping is shown in the illustration, Fig. 5. This is known as the drop-leg system, which takes care of all the condensation in the pipes and also allows for their expansion and contraction. It will be noted that at each drop leg the bottom elbow is fitted with a drip pipe which connects with the return pipe. About midway of the tunnel is a double-expansion bend which is designed to take care of expansion of the pipe in both directions. This arrangement of piping was designed by Chief Engineer Culley.

Incinerator

In the basement at the rear of the boilers there has been provided an incinerator for burning the waste from the kitchen, etc. This is constructed of masonry with cast-iron doors and is 5x10 ft.; the height is 8 ft. The grates are 24 in. wide and 36 in. deep. Back of the furnace grate there is a dumping grate 24 in. wide by 30 ft. in depth which is operated by a lever from the front.

Heating System

Both buildings are heated by the direct and indirect system. The corridors, halls, bathrooms and sleeping rooms are heated by the direct system and all reception rooms, wards and children's play rooms are heated by the indirect system. Both systems are controlled by automatic regulators and work with a variation of 1 deg. F. either way. A temperature of 70 deg. F. is maintained. For direct radiation there is a total of 125 radiators with an average surface of 75 sq.ft. The indirect system has a total of 70 radiators or stacks with an average heating surface of 125 sq.ft. These heating coils are hung from the ceiling of the plenum chamber and are incased with a sheet-iron jacket and flue connection to the flue leading to the room to be heated. The heat is controlled by a double damper which admits hot or cold air to the room as the temperature falls or rises, each room being equipped with a thermostat directly connected with the damper.

The direct radiators are connected to sets of risers, 42 in all, located in such parts of the building as to make the connections to the radiators as short as possible. Each radiator has steam-return and air-line connections. The 8-in. main heating supply passes from the boiler room to the plenum chamber, from which connections are made to the risers and stacks. Return lines from all risers, radiators and stacks are connected to a main 6-in. return which follows the course of the steam main and enters the feed-water heater in the boiler room.

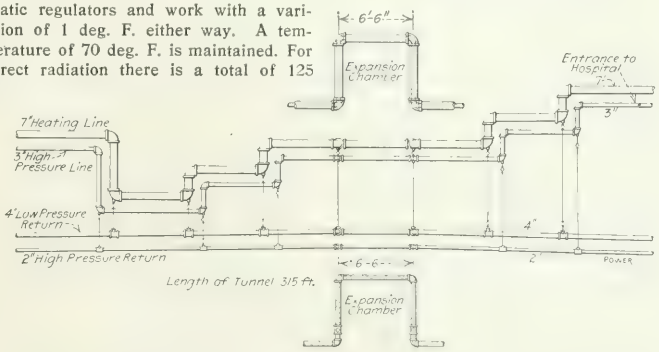


Fig. 5. How Expansion of Piping Is Taken Care of in the Tunnel

Ventilating Apparatus

The ventilating apparatus provides for the fresh cold-air supply for the boiler and engine rooms and a warmed fresh-air supply throughout the building. This apparatus also provides an exhaust ventilation from these rooms by means of exhaust fans which are located in the attic. In the basement there are two centrifugal cone-pressure fans which are used for supplying air to the entire building.

The 84-in. ventilating fan is driven by a 12½-hp. motor and each 78-in. fan is driven by a 10-hp. motor; both are of the multipolar, direct-current type. Before entering the fan, the air is washed by

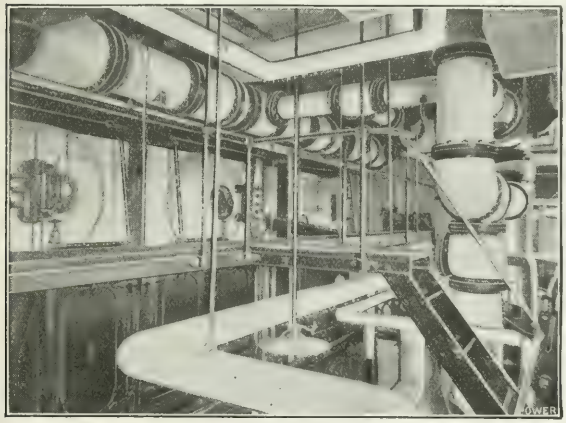


Fig. 3. Piping in Boiler Room

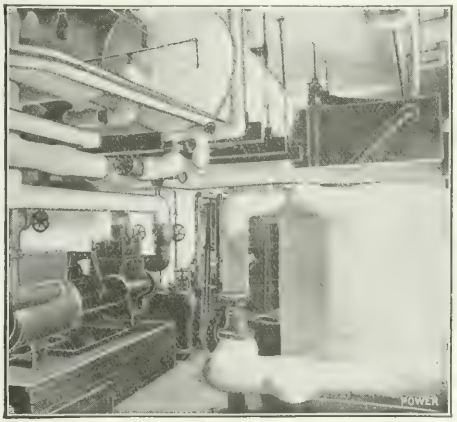


Fig. 4. Pump and Filter Room

passing a sheet of water between the inlet and the fan proper.

The filter is capable of washing and cooling 60,000 cu.ft. of air per minute and delivers it at a temperature not exceeding 5 deg. above the temperature of the water used. Before passing through the various rooms of the building, the air is tempered by means of indirect radiators which are built in four groups of tempering coils of 19 sections each, having a total of 2850 sq.ft. of heating surface. Each of the 19 sections has separate steam returns and air connections. Each air flue is connected to the main plenum chamber.

Double dampers control the admission of either hot or cold air, and they are controlled by air pressure. As the temperature falls a thermostatic valve admits the air to a valve controlling the compressed-air diaphragm which operates the damper. As the temperature in the room rises the hot-air damper is closed and the damper controlling the cold-air supply is opened, and *vice versa,* thus keeping the temperature of the room normal. This arrangement permits of controlling any indirect radiator by means of the double damper at the base of each of the 68 flues or reheating stacks, and a thermostat is placed in the room corresponding to that with which the flue connects.

The pneumatic thermostats are located at a height of about 5 ft. 6 in. from the floor in such parts of the room as will best serve to give the average temperature. The thermostats open and close the dampers to which they are connected by compressed-air pipes.

The power plant operates with a day-and-night load. It is very complete and furnishes a good example of a small modern isolated power-plant installation.

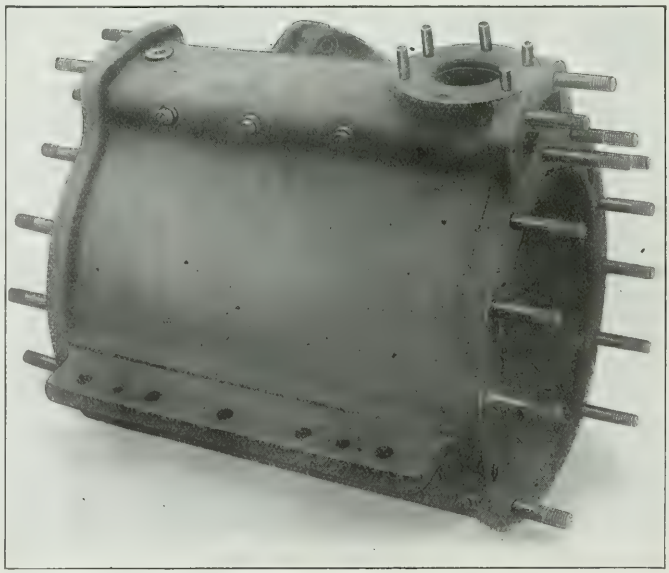
EQUIPMENT OF POWER PLANT

Equipment	Make	Purpose	R.p.m.	Horse-power	Steam Pressure, lb	Kw. Capacity	Volts	Amperes	Size, Inches	Manufacturers
2 engines	Ames	Main generator units	260		125	200			15x14	Ames Iron Works
1 engine	Ames	Main generator units	275		125	75			14x12	Ames Iron Works
3 boilers	Babcock & Wilcox	Steam generator units		150	125					Babcock & Wilcox Co.
2 generators	Sprague	D.-C. generators	260			200	245	800		Sprague Electric Co.
1 generator	Sprague	D.-C. generator	275			75	245	300		Sprague Electric Co.
3 safety valves	Consolidated	Boilers			125					Consolidated Safety Valve Co.
Grates	McClave	Shaking and dumping								McClave-Brooks Co.
Regulator	Kieley	Damper								Kieley & Mueller
Heater	Utility	Feed water		500						Standard Steam Specialty Co.
2 separators	Utility	Steam mains							5	Standard Steam Specialty Co.
1 separator	Utility	Steam main							4½	Standard Steam Specialty Co.
1 pump	Deane duplex	House service			100				6x4x6	Deane Steam Pump Co.
2 pumps	Deane duplex	Boiler feed			100				6x4x6	Deane Steam Pump Co.
1 pump	Deane duplex	Fire and tank			100				10x6x12	Deane Steam Pump Co.
2 pumps	Duplex	Air			100					Johnson Service Co.
Heating system	Johnson	Air and steam								Johnson Service Co.
4 fans	Duplex Cone	Ventilation	225						78	Howard Morse Co.
1 fan	Duplex Cone	Ventilation	200						84	Howard Morse Co.
2 fans	Duplex Cone	Ventilation	125						36	Howard Morse Co.
4 motors	Sprague D.-C.	Driving fans	450							Sprague Electric Co.
2 motors	Sprague D.-C.	Driving fans	425							Sprague Electric Co.
1 motor	Sprague D.-C.	Driving fan	450							Sprague Electric Co.
Valve	Jenkins	Piping system								Jenkins Bros.
Pipe covering	Asbestos	Steam, hot water								Robert A. Keasley Co.
Gage board	Baldwin	Steam and air								Baldwin Engineering Co.
9 gages	Ashcroft	Steam, vacuum and air								Ashcroft Mfg. Co.
Piping	Extra heavy	Steam and water								Baldwin Engineering Co.
5 traps	Kieley	Return								Kieley & Mueller
7 traps	Angell	Return								Angell Mfg. Co.
Water control.	Cutler-Hammer	Motors								Cutler-Hammer Mfg. Co.
Meter	Worthington	Water								Henry R. Worthington
3 lubricators	Rochester	Force feed								Greene-Tweed & Co.
2 filters	Roberts	House water								Roberts Filter Mfg. Co.
Air purifier	Kinealy	House supply								Kaufman Heating & Eng. Co.

Patched Air Compressor Cylinder

An ingenious repair job was recently made on an air-compressor cylinder at the No. 7 colliery of the Susquehanna Coal Co., Nanticoke, Penn.

For some unknown reason, water accumulated in the air-exhaust port of the cylinder and when the compressor was started the outer shell was cracked on both sides, as shown in the accompanying illustration. It was a case of making a hasty but permanent repair and Master Mechanic Morgan decided to reenforce the fractured part through the top and sides by means of solid stay-bolts. The stay-bolts, running from the top of the air port, extended but part way through the cylinder wall. A second set was run from the side walls of the exhaust port, as shown. The crack was then dovetailed with a cold chisel and plugged with strips of copper.



STAY-BOLTS TO STRENGTHEN CRACKED EXHAUST PORT OF CYLINDER

This repair job has lasted for three years and the cylinder was recently removed in order that it might be rebored, when it will again be put in service.

The Systematic Purchase of Coal

By F. R. Hutton* and J. L. Pultz†

An outline of the procedure employed in the selection, purchasing and use of coal for the Department of Water Supply, Gas and Electricity, New York City. With slight modifications these methods may be applied to any municipality or large user of coal.

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The systematic purchase of coal as here considered includes, first, the purchase of fuel which shall insure a maximum heating value and furnace effectiveness with a minimum operating cost, and, secondly, a systematic procedure governing the delivery, sampling, analysis and payment for coal. The procedure and its detail will not be justified in cases where the fuel required can be obtained without the use of detailed specifications. Such conditions would occur when a power plant buys direct from an operator who handles coal from a certain locality and of a desired quality. This is unquestionably the most simple method of purchase. In centers of population which draw their coal supplies from various localities, and where the coal is sold under various trade names in the local market, municipalities and large corporations have disregarded such terms, and the more scientific method of buying by analysis and heat value has been considered worth the additional trouble.

In the practice of the United States Government the contractor is paid a bonus for coal delivered which is of better quality than the standard set in the specifications. For deliveries of coal which fall below that standard, deductions are made from the contract price, proportional to the decreased value of the coal. The advantages for this system may be summarized as follows:

1. The buyer is insured against delivery of poor and dirty coal, and is saved from disputes arising from condemnation based on a visual inspection.

2. Bidders are placed on a strictly competitive basis as regards quality as well as price.

3. Trade names are ignored and the field for both buyer and dealers is broadened.

4. Delays and cost of removal are avoided should the delivered coal prove to be of poor quality after the expense of such delivery has been incurred. Rejectable coal may be accepted if its removal is inexpedient, although at a greatly reduced price.

5. A definite basis is provided for a cancellation of the contract.

6. The inspection and analysis at the intervals of installment deliveries make an easy check on the practical results in burning.

The objections in practice to the bonus feature of any system may include:

1. The quality of coal which entitles the dealer to a bonus can often be obtained without one, unless the standard is made so high as to admit too few bidders.

2. The range between the quality entitling to a bonus and that entailing a penalty may cause so wide a variation in the quality supplied at any consuming point that difficulties arise from the labor point of view in hand firing, and in securing the highest efficiency with the equipment of the plant.

3. The contractor will always see his risks of loss more clearly than his possible premiums. Therefore, he will put his price high enough to protect himself, and this is the same as raising the point when penalties will begin.

4. The bonus system puts great responsibility on the inspectors in sampling and on the chemists in their analyses.

5. The bonus system has been shown by experience in some cases to result in compelling the buyer to pay a higher cost per ton for coal.

6. There are certain cases (notably in municipalities) where the payment of a bonus or premium is prohibited by charter or other legislative restraint.

It seems better therefore, if the same or better results can be obtained in some other way, to avoid the complexity of the combined bonus and penalty system. The procedure as followed by the Department of Water Supply, Gas and Electricity for New York City is herein outlined and may be applied with slight modifications to meet any other case:

Before drawing up definite specifications a careful investigation was first made of the character of the various coals furnished in the buyer's area, and from these results a diagram was plotted as respects the moisture, ash, volatile sulphur and combustible matter, and any coals falling within the limits so outlined were put in the list of eligibles as to quality, or as not open to a penalty. Coals lying outside these limits and below them would be penalized with respect to weight but not as to price, so that the buyer should not buy water or incombustible mineral matter and pay for them at the rate agreed on for good coal. The research developed the relation that each percentage of ash in the coal besides displacing 1 per cent. of combustible matter, had a retarding effect varying with the quality of the coal, equivalent to a withdrawal of between 145 and 155 B.t.u. with an average of 150 B.t.u. With this as a basis a formula was evolved applicable both to anthracite and bituminous coal in the following form:

$$\text{Corrected tonnage} = \text{tonnage delivered} \times \left(\frac{\text{B.t.u. per pound as delivered} - 150 \text{ B.t.u.} \times \text{excess percentage of ash}}{\text{B.t.u. per pound as specified in standard analysis}} \right)$$

For practical purposes the formula can be simplified by using a direct percentage relation whereby 1 per cent. in weight shall be deducted for each 100 B.t.u. and an additional 1 per cent. for each percentage of ash. This can be equally well applied when it is desired to give a bonus. There are advantages in separating the deduction for ash into two halves as above.

The Sampling of Coal for Analysis

Standard specifications should require that coal be analyzed in a laboratory; the analysis to be made on a sample representative of the entire delivery.

Inspectors or samplers should usually be designated to check the weighing.

Two distinct cases arise in getting samples: First, for lots of over 25 tons and less than 100 tons the sample should be 200 lb.; second, for lots of over 100 tons the sample should be approximately one ton in each thousand tons, or one-tenth of 1 per cent. of the gross quantity.

If the sample is taken from a pile, take the shovelfuls from all parts of the pile, care being taken to secure equal amounts from the top, the middle and the bottom of the pile. The gross sample taken by this method should contain the same proportion of lump and fine coal as exists in the whole shipment. In order to avoid gain or loss, it should be protected from the weather by being placed in a receptacle of sufficient size and having a cover, unless the gross sample can immediately be quartered down to a small sample. If the coal is larger than pea size it should be broken by hand or by passing through a crusher to approximate the pea size of coal which will pass over a ¼-in. square mesh without going through, and will pass through a square mesh of ½-in. clear opening.

After being reduced to a standard size the coal should be thoroughly mixed by shoveling it over and over and forming it into a conical pile. The pile should then be quartered; the two opposite quarters should be rejected and the remaining two broken down to a smaller size, mixed and reformed into a similar conical pile and quartered again. This process should be continued until the

lumps are ¼ in. in size or smaller, corresponding to buckwheat No. 2, which passes over a $\frac{3}{16}$-in. mesh without falling through and passes through a ¼-in. square opening, and the sample has been reduced to what will go into a 2-qt. can or to a quantity not less than 5 lb. in weight.

The sample should be worked down as rapidly as possible to avoid change in the percentage of moisture through exposure to the air, and then be inclosed in a can fitted with a lid which screws on tightly.

Analysis of Coal

The acceptability of coal supplied under contract should be determined by a standard chemical analysis. The same analysis should determine the weights to be used in computing the amounts to be certified in the audit of the bills. The laboratory analysis serial number should be filled in upon the coal-delivery report which accompanies each sample of coal, and the serial number of the coal-delivery report should be entered upon the analysis report, so as to avoid errors. The analysis report should embody all the information contained in the coal-delivery report and in addition the following data:

Date on which sample was received at the laboratory.

The laboratory serial analysis number.

The details of the analysis, together with the specifications of the standard in regard to each constituent, and the excess of deficiency disclosed by the analysis as respects the percentage of moisture in the coal at the point of weighing, the percentage of ash in dry coal, the percentage of volatile combustible matter in the dry coal, the percentage of volatile sulphur in the dry coal, and the heat value in B.t.u. per pound of dry coal.

The same data which are covered in the foregoing list of the coal-analysis report should also be entered upon the back of the coal-delivery report.

The coal-analysis report and the coal-delivery report blanks when the entries have been completed thereon should be transmitted to the parties interested, usually one copy to the contractor, one to the chief engineer and one to the office of the company.

In addition to the provision to prevent excess of clinker, analyses should be made at proper intervals of the ash rejected from the boiler furnaces to determine the proportion of combustible going to waste.

Determination of Price

The ultimate purpose of the analysis is to test the compliance of the coal actually delivered with the terms of a standard analysis given in the specifications. The accompanying table shows the standard analysis as required by the Department of Water Supply, Gas and Electricity.

The weight of coal as certified by the inspector and reported by him to the contractor is corrected when shown by analysis to be inferior to the standard, as follows:

The weight is reduced from that given by the weighing at the point of delivery by the percentage in excess of the standard which the analysis shows.

The weight of the coal after correction for moisture is then reduced at the rate of 1 per cent. for each percentage of ash in excess of that permitted by the standard, and the gross dry weight after correction for moisture at the rate of 1 per cent. for each 100 B.t.u. below the standard heating value. The gross dry weight is corrected at the rate of 5 per cent. for each 1 per cent. of volatile sulphur in excess of the standard. These corrections are then aggregated and deducted as a whole, payment being made only for the balance of the gross weight at the price bid per unit furnished, delivered and stored and trimmed (if so specified in the schedule).

STANDARD ANALYSES—ANTHRACITE COAL

Sizes of Coal	Moisture, Per Cent. as Delivered	Ash, Per Cent. Dry Coal	Volatile Combustible Matter, Per Cent. Dry Coal	Volatile Sulphur, Per Cent. Dry Coal	B.t.u., per Pound Dry Coal
Broken	4	11	8	1.5	13,200
Egg	4	11	8	1.5	13,200
Stove	4	12	8	1.5	13,000
Nut	4	12	8	1.5	13,000
Pea	5	17	8	1.5	12,300
Buckwheat No. 1	6	18	8	1.5	12,200
Buckwheat No. 2	6	19	8	1.5	12,100
Buckwheat No. 3	6	19	8	1.5	12,000

STANDARD ANALYSES—SEMI-BITUMINOUS COAL

Run-of-mine	3.9	10	25	1.75	13,800
Lump	2.5	9	25	1.5	14,600
Nut	2.5	9	25	1.5	14,000
Slack	3.0	11	25	1.75	13,600

Procedure Relating to Coal Contracts

The procedure to procure coal will vary widely according to condition. The complicated procedure under the departmental standard contract and standard specifications of the city of New York is as follows:

1. A schedule in standard form is filled out and signed by the mechanical engineer of the borough, if there be one. If there is no mechanical engineer, then by the operating engineer or the borough engineer.

2. This schedule must then be signed in succession by the borough engineer, the chief engineer or his deputy, the deputy commissioner (except in the

THE CITY OF NEW YORK
DEPARTMENT OF WATER SUPPLY, GAS AND ELECTRICITY
ENGINEERING BUREAU

STATION No. _____ REPORT No. _____

STATION _____ MONTHLY REPORT—PUMPING STATIONS —MONTH— ENDING 191

SUMMARY OF RECORDS FROM DAILY REPORTS												EFFICIENCY RECORDS					SUPPLIES USED				
Day of Month	No. IN USE		Services in use R. T. C. D-S	FEED WATER		Auxiliary Pumping No. in Use Multiplied by No. of Hrs	Mixture of Coal and Slices	Coal Burned in 24 Hours Pounds	Water Pumped in 24 Hours Gallons	Total Lift Feet	Million Gallons Raised One Foot High	Gallons Raised One Foot High Per Pound of Coal	HORSE POWER		Total Heat of Steam at Boiler Pressure	Equivalent Evaporation From and At 212° Fahr. Per Pound of Coal	Cylinder Oil in Gallons	Engine Oil in Gallons	Greases in Pounds	Waste in Pounds	Outdoor Temperature at 12 Midnight
	Boilers	Engines		Cubic Feet to Boilers in 24 Hours	Average Temp. Deg. F								Total of Water Cylinders Per Minute	Total H. P. Per Pound of Coal Per Hr							
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
							(85) Previous Local Efficiency Standards to be Surpassed, viz														
1	Thirty One Lines in this Space One of each Day of the Month																				
2																					
3																					

33 Total Coal Burned in Pounds — 36 Average of Column 13

34 Total Gallons Pumped per Month — 37 Average of Column 15

35 Total Million Gallons Raised One Foot — 38 Average of Column 17

Engineman-in-Charge

MONTHLY REPORT OF PUMPING STATIONS

Borough of Manhattan) and the deputy and acting commissioner.

3. The schedule must specify: The quantities of coal; names and sizes of coal; points of delivery; quantities of installment deliveries; times of installment deliveries; method of weighing; unit prices, and total price.

4. It then passes to the bureau of supplies as a schedule to be incorporated into a standard form of contract. The steps in the bureau of supplies include: Revision by the contract clerk; revision by the corporation counsel; printing and correction of proof; copies to the commissioner when ready for advertisement; public advertisement; blank forms of contract issued; bids opened and tabulated; acceptance of bid recommended; advice of award sent to the comptroller; approval of sureties on the bid; execution of the contract, and notice to proceed under the contract.

Maintenance of Supply at Stations and Ordering under Existing Contracts

The coal supply and its adequacy at each station in a group of conditions such as prevail in a municipality is a matter of such vital importance that a double system of checks is considered advisable and is provided in the following:

The procedure in the case of new contracts is as stated in the foregoing section. After approval has been given, it is forwarded to the bureau of supplies for action in the contract division. After the award of the contract, the stores-control office makes the proper entries concerning kinds, prices, quantities and points of delivery, and issues the order to the contractor. Duplicates of this order are sent to the borough engineer's office and to the engineer in charge of the station which is to be supplied.

In the stores-control office a separate coal record is kept of the coal stored at each point and storage under each contract, covering quantities and kinds together with the records of analysis and corrected weights. When existing contracts are about to expire, the mechanical engineer of the borough, or, in his absence, the borough engineer, is held responsible for a notice to the chief engineer as to the need of fuel. The notice must be given in due time or when the station still has a four months' supply on hand.

The daily report of each pumping station is kept in duplicate, and contains the record of the total weight of coal of each class burned that day. The original report is mailed each day to the borough engineer, and after receiving his signature it passes to the supervising mechanical engineer for filing and preservation. A duplicate is sent to the statistical division of the department.

Whenever the balance of coal on hand at any station draws near to the minimum stock limit, the coal clerk at once reports the fact to the supervisor of stores, who in turn notifies the chief engineer.

The station man also, noting the same approach to a minimum stock limit, informs the borough engineer who issues the necessary order through the bureau of supplies for the delivery of more coal under existing contracts.

The Standard Records

Records are kept at the central office respecting the delivery, receipt and consumption of coal and the costs of generating power from such fuel. This is a function of the stores division. These records are kept on standard forms and include: the coal-scale weight book, the coal-delivery receipt, the coal-delivery report, the coal-analysis report, the coal-delivery record sheet, the coal-consumption record sheet, and the coal-audit report.

Tests

The coal called for by the standard uniform specifications may not be the best for every boiler furnace as they have been hitherto designed. The area of grate and type of grate and bar may need to be changed; the method of firing and thickness of fire may be improvable for a given fuel or mixture; the chimney draft may not be adjusted to the fuel and air spaces of the grates, and other conditions may need modifying. There is, therefore, room and need for practical tests by the engineers of the department, and these are made continually and at intervals to secure improvement.

Coal Consumption and Comparisons of Fuel Economy

The daily report of performance at the pumping stations, as now in use, gives the actual coal burned that day, and the weight or million gallons of water raised 1 ft. high by the combustion of this weight of coal at the station.

The monthly report totalizes the weight of coal burned during the month and the million gallons raised 1 ft. by the combustion of the monthly total of coal burned.

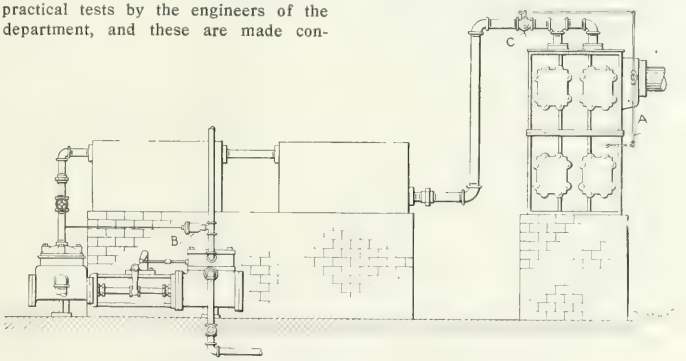
The daily and monthly reports have also been so planned as to give a continuous daily advice on the reduction of the coal supply at each station, and to eliminate any danger of exhaustion of the coal supply at any station if the blanks and the information they give are properly utilized.

Automatically Governed Feed Water Pump

A homemade arrangement for governing the speed of a service pump is shown in the accompanying illustration. The pump takes water from a river and after forcing it through two tank feed-water heaters, discharges it into an open feed-water heater from which it is taken by a boiler-feed pump and forced into the boilers.

To maintain a proper level in the open feed-water heater a back-pressure valve was placed in the inlet pipe and attached to the float of the heater, as shown at *A*. From the water end of the pump a ¼-inch pipe connection was made to a diaphragm control valve which was placed in the pump steam-pipe line, as shown at *B*.

The feed water is heated by the exhaust steam from the auxiliaries in the plant. When the water in the open heater gets to a predetermined hight, the float lifts, which closes the back-pressure valve *C*, until a back pressure of 10 pounds has been placed on the system back to the water end of the pump. This pressure is exerted on the diaphragm of the valve *B*, which closes the valve, thus slowing down the pump.



Home-made Governor for Feed-water Pumps

That the pump may not stop entirely and for convenience, a small ¼-inch pipe is run to the wash room, where the water runs continuously. By this arrangement the feed pump is running the 24 hours and the water in the heater is maintained at a practically constant hight.

Tests of Old Boilers

By Alex M. Gow*

Three return-tubular boilers 30 years old tested to destruction under hydrostatic pressure. In each the weakest point proved to be the manhole frame.

*Assistant chief engineer, Oliver Iron Mining Co., Duluth, Minn.

On June 6 and 7, 1911, three horizontal tubular boilers, designated as Nos. 301, 302 and 303, were tested to destruction with hydraulic pressure at Ishpeming, Mich. The boilers were owned by the Oliver Iron Mining Co. and had been in operation for about 30 years at No. 1 Hard Ore Boiler House, Lake Superior Mines. The boilers had been condemned on account of their age by the Hartford Steam Boiler Inspection & Insurance Co. as an unsafe risk, although they showed no signs of deterioration from their 30 years' service—there being no evidence of pitting or corrosion.

Inasmuch as it will probably be necessary to maintain a boiler plant for the next 20 years at the location where these boilers have been, it was decided to install new boilers and test the old ones to destruction to determine whether they were unfit for service, and whether any deterioration of any kind had taken place which was not in evidence from an external and internal inspection.

The three boilers were identical in construction with the exception that boiler 302 contained 112 three-in. tubes, while boilers 301 and 303 each contained 83 four-in. tubes. The accompanying drawing, Fig. 1, shows the construction of the boilers. It will be observed that each boiler consists of five courses of 3/8-in. sheets, double lap-riveted with 3/4-in. rivets, spaced on 2-in. centers.

Pressure was obtained from a hand pump capable of producing a pressure of 300 lb., and, in addition, the pump of a hydraulic wheel-press was connected to the water line for additional pressure as required.

To determine the expansion of the shell, a steel tape was passed around the boiler and the movement of the tape was observed to determine the increase in circumference of the shell. Attempts were also made to determine the diametrical expansion with a micrometer gage set against the side of the boiler, but the observations on this gage were not satisfactory. The measurements upon the steel tape, however, were fairly accurate.

Boiler No. 302

This boiler was built about 1877 by Kendall & Roberts, of Boston. The sheets bore the brand "Bay State Homo." The accompanying log of the test, made June 6, 1911, gives in detail the behavior of the boiler under the successive pressures to which it was subjected.

At 275 lb. pressure, the cast-iron manhole frame broke in two with a loud report and the sheets were ruptured as shown in Fig. 2. At the time of the rupture, the steel tape showed that the circumference of the boiler had elongated approximately 3/16 in. After the rupture the tape resumed its initial position, indicating that at 275 lb. pressure the shell had taken no permanent set. While there had been some leaking of longitudinal seams, there was no evidence of serious distress at any part of the boiler. The heads showed no sign of bulging and the tube ends remained tight.

TABLE 1. LOG OF TEST, BOILER NO. 302

Time	Pressure, Lb. per Sq. In.	Observations
10:12		
10:14	60	
10:15	95	
10:18	100	
10:18½	125	1/16-in. elongation in circumference
10:20	140	
10:20½	170	
10:21	180	Seams weeping slightly
10:21½	195	
10:22	200	3/32-in. elongation in circumference
10:22½	210	
10:24½	220	
10:25	230	1/8-in. elongation in circumference
10:25½	240	All longitudinal seams leaking
10:27½	250	
10:28	260	
10:28¼	275	Manhole frame broken

Test pieces cut from the shell immediately over the fire showed an average tensile strength of 60,460 lb., with 22.5 per cent. elongation, 53.7 per cent. reduction in area and an elastic limit of 36,690 lb. The analysis of this sheet showed: Carbon, 0.13; sulphur, 0.026; phosphorus, 0.097; manganese, 0.27. The test pieces were cut both transversely and longitudinally of the sheet, but it was impossible to tell from the way the test pieces broke in which way the sheet had been rolled. It is very evident that there had been no deterioration of the steel in this sheet. Test pieces were also taken from a sheet at the top of the boiler, where it was not subjected to the action of the fire. These test pieces gave an average of 70,145 lb. tensile strength, with an elongation of 20.12 per cent., an elastic limit of 39,060 lb. and a reduction of area of 47.05 per cent.

In addition to the test pieces cut from the sheets as mentioned, a section was taken out of the longitudinal seam. Upon being pulled in the testing machine, the joint gave an efficiency of 60 per cent. of the plate, breaking through the rivet holes. This seam showed no evidence whatever of deterioration and was as good as the day it was laid up. Subjected to cold bending tests, the test pieces from the sheets above the fire bent to 180 deg., flat, without fracture.

Boiler No. 303

Boiler No. 303 was built about 1879 by Kendall & Roberts, of Boston. The sheets bore the inscription "Nashua Iron & Steel Co., Nashua, N. H.," and an encircled Indian head, and were stamped "cast steel, 60,000 lbs." Inasmuch as this boiler was identical in construction with boiler No. 302, which had developed its weak point in the manhole frame, and as it was desired to put a greater pressure on the boiler than the manhole could stand, it was decided to remove the frame and put on a 5/8-in. patch, secured by patch bolts, in place of the cast-iron frame.

On the morning of June 7, pressure was applied to the boiler in the same manner as to boiler No. 302 the day before. The log shown in Table 2 gives the observations in detail:

TABLE 2. LOG OF TEST, BOILER NO. 303

Time	Pressure, Lb. per Sq. In.	Observation
10:00	15	
10:01½	20	
10:01½	30	
10:03	90	
10:03¼	110	1/16-in. elongation in circumference
10:05	150	
10:05½	160	Seams begin to weep
10:06	170	
10:06½	180	3/32-in. elongation in circumference
10:07½	220	
10:08	225	1/8-in. elongation in circumference
10:08½	240	One girth seam leaking.
10:09½	250	5/32-in. elongation in circumference
10:11	270	
10:11½	275	3/16-in. elongation in circumference
10:12½	280	
10:13	285	7/32-in. elongation in circumference; tubes beginning to leak
10:15	295	
10:16½	297	Could obtain no more pressure by hand pump; pressure let down and hydraulic pump cut in. Boiler resumed its normal diameter; no permanent set
10:25	175	
10:26	195	1/16-in. elongation in circumference
10:27½	255	
10:28½	275	
10:28¾	295	
10:29	300	1/32-in. elongation in circumference
10:30	300	Seams leaking badly and some leaking at the ends. Stopped pumping to calk one patch bolt and tighten one plug
10:34	...	Pressure let down
10:45	...	Started pumps again
10:46	125	
10:46½	145	Stopped pump to roll one tube
10:53	145	
10:55	160	1/32-in. increase in circumference
10:55½	180	
10:55¾	210	1/8-in. increase in circumference
10:56	230	
10:56½	50	3/32-in. increase in circumference

10:56¼	270	
10:57		¼-in. increase in circumference
10:57½	285	
10:57½	295	Tubes leaking. Head shows signs of distress
10:58	300	Beading on tubes is sprung
10:59½	295	⅜-in. increase in circumference
11:00	300	13 patch bolts sheared

At 300 lb. pressure the patch and one plug began leaking so badly that the pumps could not gain, and it was necessary to reduce the pressure and calk the leaks. At 10:45 the pressure was again applied and upon obtaining 300 lb., there was noticeable distress on one head, with leaking of tubes and springing of the beading. The steel tape indicated that the boiler was increasing in diameter. The leaks were such that the two pumps were not able to gain over 300 lb. pressure, and at this pressure 13 of the patch bolts sheared. The manhole sheet expanded approximately ½ in. with no rupture. It being impossible to replace the patch, and the head having shown evident distress, no further attempt was made to burst the longitudinal seams. The steel tape showed that the boiler had expanded about ⅛ in., and it did not resume its normal diameter.

Test pieces cut from the sheet immediately over the fire showed a tensile strength of 60,186 lb.; elastic limit, 38,280 lb.; elongation, 21.5 per cent., with 54.52 per cent. reduction of area. Analysis of the steel gave: Carbon, 0.17; sulphur, 0.023; phosphorus, 0.097; manganese, 0.29. Test pieces cut from the sheet at the top of the boiler showed a tensile strength of 56,400 lb.; elastic limit of 37,230 lb., and an elongation of 27.25 per cent., with 64.88 per cent. reduction of area. Analysis of this steel showed: Carbon, 0.25; sulphur, 0.021; phosphorus, 0.092; manganese, 0.37.

Boiler No. 301

Boiler No. 301 was identical in construction with boiler No. 303. It was purchased at the same time and the sheets bore the same brand. It was tested in the same manner, and the log of the tests in Table 3 shows the observations:

At 260 lb. pressure the manhole casting broke in identically the same manner as that upon boiler No. 302, first tested. The steel tape, however, showed that the boiler had taken a permanent set of ⅛-in. elongation in the circumference, probably due to slight movement of the longitudinal seams, which showed signs of distress.

Test pieces taken from a sheet immediately over the fire showed a tensile strength of 60,780 lb.; elastic limit, 33,100 lb.; elongation, 26.5 per cent.; reduction of area, 61.62 per cent. Analysis as follows: Carbon, 0.13; sulphur, 0.022; phosphorus, 0.105; manganese, 0.20. Test pieces taken from the top of the shell, not subjected to the fire, showed a tensile strength of 61,680 lb.; elastic limit of 38,820 lb.; elongation, 19.75 per cent., and a reduction in area of 50.80 per cent. Analysis as follows: Carbon, 0.18; sulphur, 0.022; phosphorus, 0.085; manganese, 0.28.

The tests for tensile strength and the chemical analyses were made at the works of the Illinois Steel Co., South Chicago, through the courtesy of P. E. Carhart, inspecting engineer. Twelve test pieces were measured with a micrometer and showed a maximum thickness of sheet of 0.380 in.; minimum thickness, 0.364 in.; average, 0.373 in. This variation in thickness is no greater than would be expected in nominal ⅜-in. boiler plate, and showed that there had been no appreciable reduction of thickness by reason of corrosion on the surface of the plates.

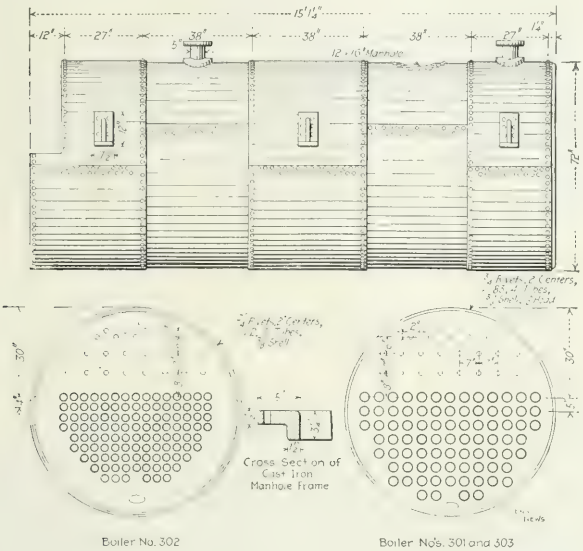


FIG. 1. DRAWING SHOWING CONSTRUCTION OF 30-YEAR OLD BOILERS TESTED AT ISHPEMING, MICH.

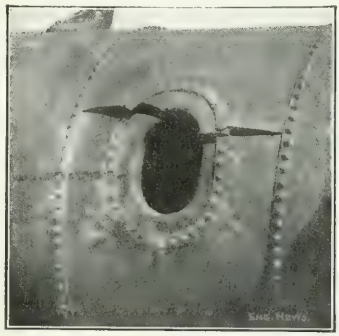


FIG. 2. PHOTOGRAPH SHOWING MANHOLE FRAME OF BOILER 302 AFTER FAILURE AT 275-LB. PRESSURE

The boilers had been originally built to carry 100 lb. pressure, but inasmuch as, allowing the longitudinal seams an efficiency of 60 per cent. of the plate, this would give a safety factor of but 3.75, the working pressure had been fixed at 80 lb., giving a safety factor of 4.70. It is evident that the weak point of each boiler was the cast-iron manhole ring. Boiler No. 301 broke at this point at a pressure of 260 lb. With the pressure of 80 lb., the safety factor at this point was, therefore, but 3.25.

Had this cast-iron manhole ring broken in service it is not probable that an explosion would have resulted. Fig. 2 shows a ruptured sheet from boiler No. 302. This rupture occurred when the manhole ring broke at a pressure of 275 lb. When the manhole ring on boiler No. 301 broke in identically the same manner, at a pressure of 260 lb., the sheet was not ruptured. Furthermore, when the patch bolts sheared at a pressure of 300 lb. on boiler No. 303, the

TABLE 3
LOG OF TEST, BOILER NO. 301, JUNE 7, 1911

Time	Pressure, Lb. per Sq.In.	Observation
11:15		Pump started
11:15½	55	
10:17	85	
10:17½	100	
10:18½	150	¼-in. increase in circumference
10:20	155	
10:20½	180	Seams weeping
10:21	205	Flues leaking a little
10:21½	225	
10:22	235	Leaking at manhole
10:22½	250	⅜-in. increase in circumference
10:23½	255	
10:24	260	Manhole broke; ½-i increase in circumference

sheet was not ruptured. It is fair, then, to assume that had a manhole ring let go in service at a pressure of from 80 to 100 lb., no rupture of the sheet or explosion of the boiler would have followed. But upon this point there is room for a difference of opinion.

SUMMARY

It is evident from the above tests that there had been no deterioration in the quality of the material, and it was such as would pass today for good boiler plate. The one sheet from the top of boiler No. 302, that had a tensile strength of 70,000 lb., showed slight cracks under the cold-bending test to 180 deg., flat. The fracture in every case was good and no one of the test pieces showed the slightest indication of lamination or lack of homogeneity.

All in all, the boilers were as good as the day they were made; the material was excellent, the workmanship was admirable and subject to only one criticism—the rivet holes had not been reamed. With this exception, the workmanship could not be improved upon. In no way, shape or form had the boilers deteriorated by the 30 years' service to which they had been subjected; the water furnished had been of uniformly good quality; they had received excellent care and attention. At times they had been fired very hard, sometimes with wood, sometimes with coal, at other times with a mixture of wood and coal.

It is interesting to note in this connection that the Bay State Iron Works, which made the steel for boiler No. 302, had, according to a list of rolling mills and steel works published in 1882, one 6-gross-ton Siemens openhearth steel furnace, with an annual capacity of 2800 net tons of ingots. The Nashua Iron & Steel Co., Nashua, N. H., had one 10-gross-ton Siemens openhearth steel furnace. These furnaces must have been among the earliest Siemens openhearth furnaces built in the United States, and these boilers among the very early ones built from such material.

Boiler Explodes at Knoxville, Tenn.

By John Mathie

Explosion of a locomotive type of boiler resulting in two deaths and several injured. The lower valve on the water gage was found closed and presumably the fireman had been running on a false water level. Also the safety valve was screwed all the way down.

The accompanying photographs show the remains of the boiler which exploded at the quarry of the Royal Marble Co., near Knoxville, Tenn., on Feb. 5, killing the fireman and his brother, who happened to be present at the time. The boiler was of the locomotive type, carried on skids and furnished steam to run rock drills at the quarry, five being in operation at the time of the explosion.

On Jan. 28, 1912, the boiler had been inspected by a well known insurance company and had been pronounced safe to carry 100 lb. pressure.

Fig. 1 is a general view of the quarry and the adjoining field after the explosion, showing (1) the location of the boiler house; (2) where the main portion of the boiler landed, 350 ft. from its original location; (3) where the front landed, 150 ft. in the opposite direction, and (4) the place at which the bodies of the fireman and his brother were found.

At one corner of the boiler house there stood an electric-light pole carrying two transformers. Both of these were destroyed, one being hurled a distance of 120 ft., and, in all, three poles were knocked down.

A man passing the boiler house at the time of the explosion was struck by a barrel used for supplying water to the boiler, and was carried a distance of 75 ft., where he dropped to the ground, while the barrel bounded 15 ft. farther, turned over and emptied. The man had one arm broken in two places, a leg broken and three ribs.

Fig. 2 shows the boiler in its final position, and Fig. 3 is a view of the front, showing how the crown-sheet tore from the stay-bolts and braces. This piece landed on several men working in the pit and more or less injured all of them. Fig. 4 is another view of the same piece.

FIG. 1. LOCATION MARKED 1 SHOWS WHERE BOILER ORIGINALLY STOOD; 2 SHOWS WHERE MAIN PART OF BOILER WAS HURLED; 3 WHERE FRONT OF BOILER WAS FOUND AND 4 WHERE THE BODIES OF THE FIREMAN AND HIS BROTHER WERE FOUND

Particular attention should be paid to Fig. 5, which shows the safety valve that was on the boiler. It will be observed, upon looking closely, that the valve had been screwed down until the coils of the spring were pressed one upon the other. This valve could not open under any pressure and instead of being a factor of safety it was, as it proved to be, a menace to life and property.

When tested with water at a pressure of 130 lb. per square inch after the explosion, not a drop came past the disk. This valve had been set at 100 lb. and the gage was tested on Jan. 28, 1912. Therefore the question is—Who screwed down the valve?

A fusible plug had been put in the boiler about one month before the explosion, and upon examination the fusible metal in the plug showed that it had melted, but the face of the plug in the boiler appeared to have been scaled over, thus preventing the metal from dropping. In view of this it would seem a good idea for all engineers who have fusible plugs in their boilers to scrape them until they show bright every time the boilers are cleaned.

Upon inquiry, the writer learned that the fireman had closed both valves on the water gage the night before the explosion and in the morning had only opened the top valve as the bottom valve was closed when found. This would indicate that he had run from 6 a.m. until 10:30 a.m., thinking the water shown in the glass was the true level.

National Coating

National Coating is a preparation which is supplied to piping ranging in sizes from 3 to 18½ in. outside diameter. Its purpose is to prevent external corrosion and electrolysis.

When a pipe is to be coated, it is first cleaned and dried and dipped in a special bath, and upon being dried is left with an inside and outside coating of an elastic compound. This enamel-like surface is wrapped with a strip of fabric which has also been thoroughly saturated in the hot compound. It is wound spirally over the surface of the pipe, about 1 in. on each turn. Two or three thicknesses may be applied in this way when desired to meet special conditions. The covering firmly adheres to the body coat of the pipe. The main purpose of this covering is to protect the pipe from moisture.

National Coating is manufactured by the National Tube Co., 1106 Frick Building, Pittsburg, Penn.

New Insulating Tape

The Westinghouse Electric & Manufacturing Co., Pittsburg, Penn., has recently placed on the market a bias-cut treated cloth tape which is made under a new process and for which some very satisfactory characteristics are claimed. It can be used as continuous tape, having a good tensile strength throughout its entire length, or may be divided into 4-ft. lengths by tearing, or without the use of any cutting tool. There are no sewed seams which, when present, have to be cut to make a neat job.

This tape also has the same dielectric strength throughout its length as the full-width treated cloth. It is also free from

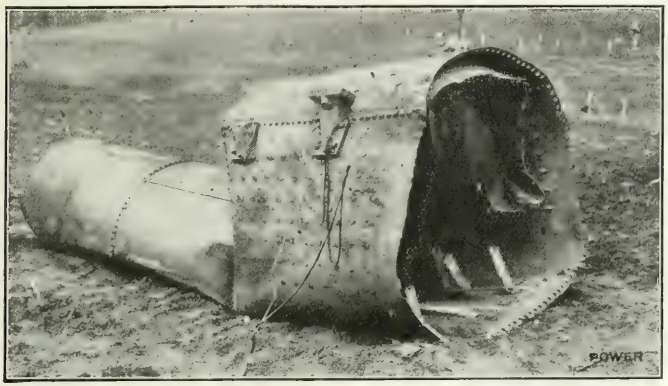


Fig. 2. Main Part of Boiler After Explosion

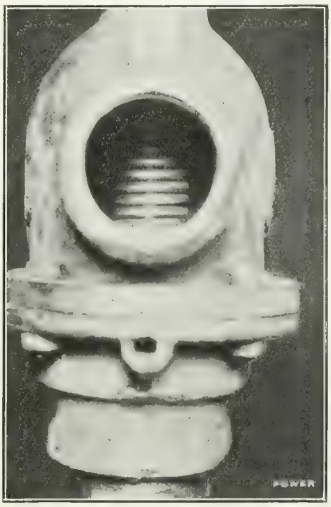


Fig. 5. Safety Valve with Spring All the Way Down

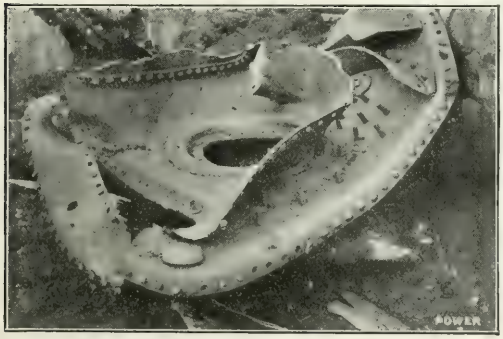


Fig. 3. Front of Boiler

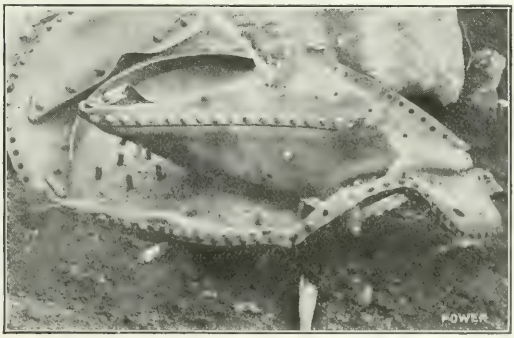


Fig. 4. Showing How Crown Sheet Tore

uneven places due to the running of the insulating liquid which collects in the sewed seams during the process of treating.

This new process tape has also been specially designed to have the best possible amount of grip and slip; that is, it has a degree of tackiness that particularly adapts it for taping purposes.

Reinforcing Van Stone Joints

By W. N. Stevens

To those who have not analyzed the strains on a van stone joint, it may seem reasonable to assume that by reinforcing the metal in that portion of pipe flanged out to make the joint, additional strength is obtained. This, however, is not the case. Pipe is made from plates which are rolled from an ingot and bent over and welded. As the van stone joint is made while the metal is hot, it is not injured in being flanged out for the same reason that rolling does not injure the plates.

The illustration shows the approximate dimensions of a van stone joint on an 8-in. pipe. If the thickness of the flanged-out portion at *A* (1 in. from the bore) is 75 per cent. of the shell of the pipe at *B*, then there is exactly the same area of metal to resist tension at *A* as there is at *B*. As the flange has the same radius of curvature as the pipe, it is obvious that only a very small part of the tension at *B* can be transmitted around to *A*.

Van stone joints are made in a machine and consequently only a very thin cut is necessary to provide a steam-tight joint between the pipes, and when finished the area of the metal at *A* is rarely less than 80 per cent. of that at *B*. It should be borne in mind that this refers to the area of metal that resists fracture.

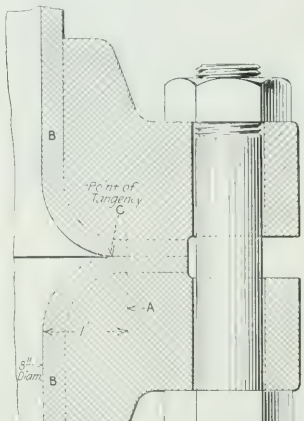
Assume, however, that the flanged-out part has been turned off until the area of metal at the point of tangency *C* is one-half that at *B*, also that bolts have been provided of sufficient strength to withstand the hydrostatic pressure required to break the pipe. As the pressure required to burst the pipe is 4000 lb. per square inch, assuming a tensile strength of 50,000 lb. per square inch, and the cross-sectional area within the pipe is 50 sq.in., there will be 200,000 lb. exerted along the pipe. The area of metal in the circular section at *B* is 8.4 sq.in. and the metal will therefore be under 24,000 lb. per square inch longitudinal stress. As assumed, there is only half the metal at *C*, and if all this stress could be transmitted to *C*, there would be 48,000 lb. per square inch tension at *C*, which is less than the bursting strain at *B*. The pipe would therefore burst before the joint would break, because it is impossible to transmit all the strain around the corner.

How, then, can reinforcing the flanged-over part add strength if the area of metal at *C* is one-half of that at *B*? In order to answer this, look at the matter from another point of view. The sectional area of metal in an 8-in. standard weight pipe is 8.4 sq.in. An extra-heavy 8-in. flange has twelve ⅞-in. bolts. The area of metal in a ⅞-in. bolt, at the bottom of the thread, is 0.42 sq.in. The area of the 12 bolts is

$$12 \times 0.42 = 5.04 \ sq.in.$$

There is therefore 66 per cent. more metal in the shell of the pipe than in the bolts.

In order to make a tight joint the bolts must be screwed up hard, and they are under a considerable stress in addition to that transmitted to them by the pipe, and all of the stress in the pipe is transmitted to the bolts. It is impossible to estimate what this initial stress on the bolts will be, but the factor of safety of the bolts is rarely one-fourth as large



Section through Van Stone Joint

as that of the pipe if the joints are tight.

From this point of view it is clear that nothing is gained by reinforcing the flanged-out part of the pipe, as the bolts cannot hold one-fourth the pressure necessary to burst the pipe.

The foregoing figures have been based on an 8-in. pipe, but it will be found that the other sizes will lead to the same conclusions.

While it is very desirable to improve van stone joints and incidentally the joints between fittings in high-pressure steam piping, this discussion shows that improvements must begin at the weakest point to have any value whatever, and the weakest points are the bolts.

To bring the factor of safety of the bolts up to that of the flanged-over portion of the pipe in a van stone joint, even after half of the metal has been turned off, at least four times as much metal should be put in the bolts.

Actuating Forces in Straight Line Air Compressors

By Frank Richards

The questions which have recently been current in the pages of Power as to the direction in which the crankshaft of a straight-line air compressor should run, and also as to the peculiar knocks sometimes accompanying the crosshead movements in compressors of this type, suggest the following analysis toward a clear and final understanding of the matter:

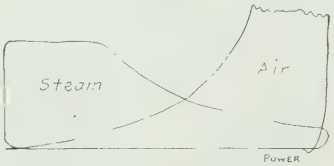


Fig. 1. Combined Air and Steam Diagram

It is well known that in the horizontal steam engine, if the crankshaft runs over, the crosshead pressure is always downward; while if the crankshaft runs under, the resultant vertical forces at the crosshead are reversed, and are usually more than sufficient throughout the stroke to overcome the weight. In the air compressor the conditions are very different, no matter which way it runs.

Consider the typical combined air and steam diagram, Fig. 1, which might be from any straight-line compressor, the cylinders being assumed to be of equal diameter. In the earlier portion of the stroke the steam pressure is greatly in excess of the air resistance, and the surplus of power must be disposed of in increasing the momentum of the flywheel. At the point where the steam-expansion line and the air-compression lines cross, the pressure in the steam cylinder just equals the resistance in the air cylinder, and beyond that point to the end of the stroke the steam pressure must be assisted by the momentum of the flywheel. The inadequacy of the steam to maintain the running really begins before the point is reached where the lines cross, because there is the entire friction of the machine to be overcome and the running speed to be maintained, so that the actual reversal of the balance of the driving forces occurs very near midstroke, no matter in which direction the crankshaft turns.

The story of what happens is told graphically in Figs. 2 and 3, and it would seem that little explanation is required. In Fig. 2 the shaft runs over and in Fig.

3 it runs under. At the crosshead the + sign indicates that it is pressing against the guide while the — sign indicates the reverse. The vertical arrows at each side of the midstroke line indicate the direction of the vertical thrust of the crosshead for that portion of the stroke. The horizontal arrows indicate the direction of the travel of the crosshead.

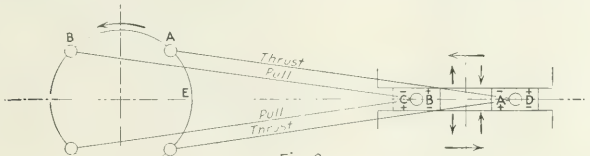


Fig. 2

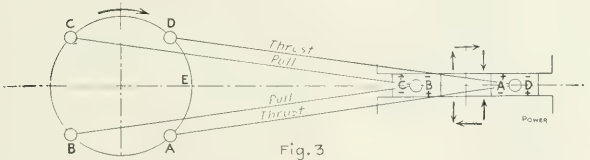


Fig. 3

FIGS. 2 AND 3. REPRESENTING GRAPHICALLY THE PRESSURES ON THE CROSSHEAD AND PIN

It will be seen that there is but one reversal (and back again) of the connecting-rod stress for the revolution. Running in either direction, there is a thrust for about one-half of the revolution and a pull for the other half. The crosshead, however, shows four consecutive reversals of vertical thrust for each revolution. If there is any conclusive reason why the crankshaft should turn in one direction in preference to the other, the writer has failed to discover it.

Taking Measurements for Plans

BY A. E. DIXON

It looks easy to measure up something, a building, for instance, so you can make a plan of it. It is not so difficult either, but it is an easy thing to fall down. The falling down comes from forgetting to take some essential dimension more than from any other cause. This is particularly aggravating when one has to travel any distance to obtain the missing information. In this kind of work it does not pay to trust to the memory; a memorandum sketch will prevent one from removing surplus hair by the diligent scratching which accompanies the effort to stimulate the brain into recalling details.

The sketch in Fig. 1 shows the field measurements taken in preparing a plan of an engine room. These measurements were taken with a 100-foot steel tape graduated in feet, inches and eighths of an inch. One corner of the building was taken as a base and the tape was used to obtain the distance from this corner to the side of every opening and projection on the wall. A sketch plan was first made. This plan was exactly like Fig. 1—in fact, it was Fig. 1, without any of the dimensions. There was no effort to work to scale, the sketch being made to show only the features of which the location was required with ample space to add the dimensions. The projection of the pilasters was measured at several points and the thickness of the wall was taken at several of the openings, the average being used. These dimensions tie the external and the internal dimension together. In actual cases it is rare for the measurements to balance up as neatly as those given on the sketch, owing to the small unavoidable errors of workmanship which occur in building construction. There is an ancient saw that a mason's eighth of an inch is the thickness of the handle of his "sword" (trowel); therefore, provided these dimensions agree with reasonable margins, they can be assumed as correct. Window frames are frequently set and bricked and may vary an inch or two in location.

In locating the engine two sides of the room are used as base lines and the center lines of the piston rods and the shaft are located. The engine may be slightly out of square with the room; in fact, the room itself may be out of square. This can be tested by running

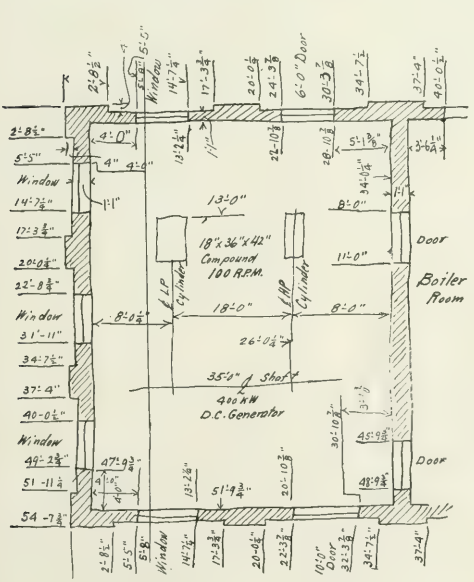


FIG. 1. FIELD SKETCH OF ENGINE HOUSE

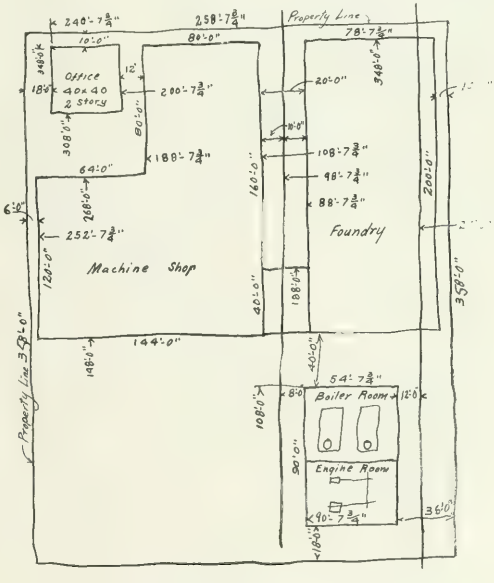


FIG. 2. FIELD PLAN OF PLANT LAYOUT

a line through the room and extending out through two opposite windows. This line should then be carefully located with reference to two corners of the building. A fine wire stretched tight makes the best sort of a line. The distance from this line to the wall should then be carefully noted at a number of points.

The next problem is to locate another line at right angles with the first. This can be done by transferring the original line to the floor by the aid of plumb bobs; a right-angled triangle is then laid off, and the second line located in this manner is used to check up the other walls.

The laying out of a right-angled triangle is not difficult. Any triangle whose sides are in the ratio of 3, 4 and 5 includes one right angle, that made by the sides 3 and 4. The length of the sides is not important, but the ratio is, and the bigger the triangle the more accurately it can be laid out. That is, a small error in laying out this triangle when the sides are 30, 40 and 50 feet long leads to a smaller percentage of error in the final result than the same error in the sides of a triangle whose dimensions are 3, 4 and 5 feet.

When it is desired to locate the building measured up with reference to other buildings or by the property lines, similar means can be adopted as illustrated in the sketch in Fig. 2, which is supposed to illustrate the plant layout. The property lines at the right and at the bottom have been taken as base lines from which all of the buildings have been located.

In making elevations it is a good plan to take the main-floor level as elevation + 100 feet and use this as the third reference plane. Where a Government bench mark is available a permanent bench can be made on the property and tied in with the Government bench mark by a surveyor. When a Government bench is not available the railroad whose spur connects with the plant can supply levels covering its track and a bench mark can be laid off from this. The assuming of elevation 100 for the bench mark will avoid all negative elevations in cellars and pits.

Cylinder Head Blew Off

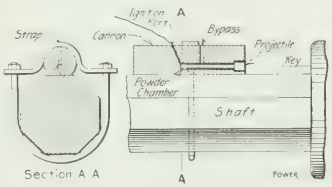
On Feb. 7 a cylinder head of a lighting engine in the Hotel Jermyn, Scranton, Penn., blew off and injured three employees. These men had been detailed to examine the cylinder. They closed the throttle valve, also the drip valves, took all the nuts off the studs and then after a light tap with a wrench or hammer the cover suddenly blew off.

It seems that the throttle leaked badly and soon filled the cylinder with steam and water. With the drips and exhaust closed there was no chance for its escape and taking all the nuts off the studs before loosening the head allowed the steam to rush out and scald the men. Two of the men were badly scalded and were sent to the hospital. They will recover, however, and will probably be more careful next time they have a job like that to do. The third man was cared for in the hotel and continued his watch.

Shooting Out Keys

By R. D. Tomlinson

I am reminded by the article in the Jan. 30 issue of Power, telling of the use of dynamite for removing a pinion from a shaft, of an experience which I had some years ago when in charge of a machine shop. Our work was to keep in repair over forty steamboats used for towing purposes; also, the machinery in the street-railway power plant and several cement mills. It frequently happened that we were called upon to make quick repairs, and it would tax the ingenuity of our best men to know how to handle some of them.



Cannon for Shooting Out Keys

The company owned, in addition to the regular tugboats, some old side-wheel steamers which were very useful in towing; the engines had wooden frames. In one of them the frame would spring so badly that it was necessary to take off the cylinder top and turn off an inch on the inside in order to prevent the piston striking either the top or the bottom. If the engine was lined up before the coal was on board it would be way out of line as soon as she took on her cargo, and when it was lined up with all the coal on board, by the time the boat got to the end of the trip, the engine was way out of line. To remedy this we used to line up with about one-half the regular amount of coal on board.

One afternoon a large side-wheeler was towed into the dock with a broken shaft, the break being just inside of the wheel house, between the spring bearing and the hub for the first set of arms. These paddle wheels were made of wood, except the shaft and hub; the shaft, where it went through the hub, was octagon, and the hub was staked on with keys. As the boat ran down the river into salt water and the keys had been driven in many years before, they were badly corroded. It was impossible to start them with a sledge, there was no room to swing a ram, and at first it looked like tearing the wheel house all to pieces in order to get that shaft out.

Our superintendent made a suggestion which was at first somewhat startling, but after thinking it over, we concluded it was worth a trial, as it was a serious matter to tear down the entire wheel house in order to get at the job. His suggestion was to make a cannon and shoot the keys out.

We planed a piece of 6-in. steel flat on one side so that we could clamp it on to the shaft; then we bored the cannon about 1½ in. in diameter, turned up a steel projectile with a hardened end and drilled a hole down into the bore of the cannon at a point where the projectile would pass it at the time it struck the key, the object of which was to relieve the pressure in the cannon without shooting the projectile out of the gun. If we had done that, it would have been lost as the work had to be done over open water.

After we had the gun finished we took it out in the yard and shot at some marks, using ordinary blasting fuse to ignite the powder. Then we strapped the gun on to the shaft, loaded it up, put in about 4 ft. of fuse, which gave the man who lit it plenty of time to crawl out of the wheel house and get back of the engine room.

The first shot gave the key a heavy jar, but did not start it. We put in a little more powder next time, and were delighted with the result; the key had started about ¼ in. We gave it one more shot and then drove it out with a sledge. It was an easy matter afterward to get the rest of the keys out.

This method of starting out rusty keys is somewhat unusual but very effective, and some engineer who reads this article may have a condition arise where he can get out of very serious trouble in the foregoing manner. It is advisable that the engineer who tries this scheme do a little experimenting with his gun before shooting out the keys to find out how much powder he needs, and use a fuse long enough for him to get out of the way. Guns have been known to burst, and the material he has at hand out of which to make his gun is not apt to be up to government specifications.

A proposition has been presented to the Ministry of Public Works for utilizing the rapids of the Salto Grande Falls in the Uruguay River, some 15 miles above the city of Salto, to generate electrical energy for transmission to towns on both banks of the river and ultimately to Buenos Aires and Montevideo. The project also includes the construction of navigable channels through the rapids and a plan for irrigation. The operations are to be commenced with a proposed capitalization of $12,000,000, and a concession for a term of 90 years.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Mathot Suction Producer

The reactions which take place in a gas producer, namely, the dissociation of steam for generating hydrogen, and of carbonic acid for producing carbon monoxide, as well as the generation of steam, are endothermic operations; that is, operations absorbing heat. It is, of course, essential, for good efficiency, to abstract the minimum possible heat from the burning fuel for performing these operations and also to recover the heat from the gas generated by utilizing it for evaporating water, or for superheating the steam and preheating the air required for combustion.

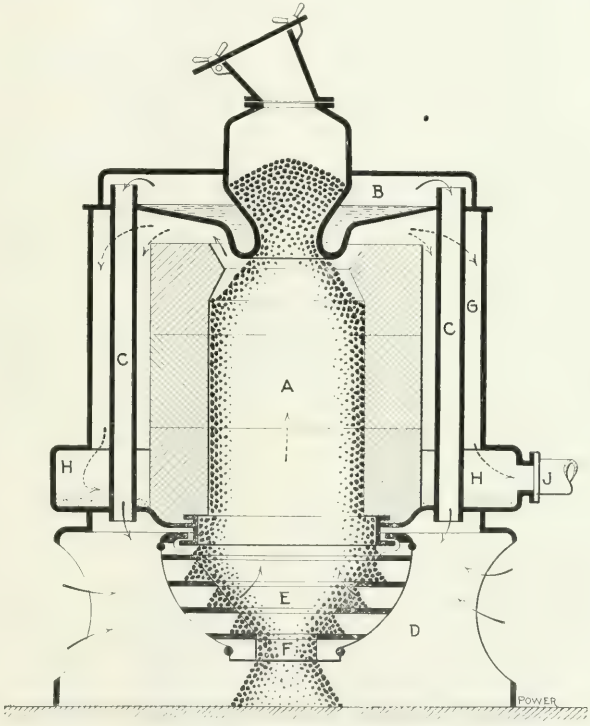
In certain producers the steam is generated in a compartment or vessel surrounding the lower part of the gas generator by means of part of the heat liberated by the combustion of the fuel. This process is detrimental to economy unless required for preventing formation of clinker when using certain coals.

In other cases, when working at reasonable loads, the gas leaves the outlet of an ordinary generator at a temperature ranging from 600 to 700 deg. F. and for cooling this gas before entering the engine a large amount of water is required in the scrubber (from three to four gallons per brake horsepower-hour). Consequently, much sensible heat is wasted which could be partly recovered and used to advantage in generating steam and assisting the endothermic conversions of the CO_2 and H_2O, at the same time reducing the quantity of water used in the scrubber.

The foregoing considerations have led Mr. R. E. Mathot, the well known Belgian engineer, to work out what he designates a recuperative producer. The construction of the generator is illustrated by the accompanying sectional drawing in which *A* is the fuel chamber, lined with brick and provided with the usual hopper; *B* is a water vaporizer; *C, C* are pipes by which the steam goes down from the vaporizer *B* to the ashpit *D; E* is a basket grate; *F* is an opening for depositing ash and clinker; *G* is a gas chamber surrounding the brick lining of the fuel chamber; *H* is a dust collector, and *J* is the gas outlet.

The grate is hung freely under the firebrick lining and is formed with a series of flat horizontal bars, stepped to from the "basket"; the fuel and ash rest both on the bars of the grate and on the heap formed under the opening *F*. Mr. Mathot states the distinctive features of the producer as follows:

The basket grate affords an area of air inlet about double the cross-section of the fuel bed and four times that of the free space between the bars of the ordinary flat grate. This, as well as the shape of the bars of the basket grate, Mr. Mathot states, allows burning any kind of low-grade coal of the smallest size without unduly restricting the air passage.



MATHOT'S SUCTION GAS GENERATOR

The steam being fed to the fuel independently of the air and the latter being always freely admitted in the open ashpit, the proportion of steam to air cannot be disturbed by cleaning out the ashpit; in the ordinary suction producer, opening the ashpit permits a large volume of air to get in without a corresponding increase in the steam, and the gas is impoverished.

The gas, instead of being withdrawn from the top, leaves the generator shell at the bottom after having passed around the brick lining for preventing external radiation of the heat of the combustion zone. In passing down to the exit, the gas gives up sensible heat to the steam, which is therefore superheated before reaching the fuel bed, allowing a greater quantity of steam to be dissociated without cooling down the fire. This, of course, gives a greater amount of hydrogen in the gas and a higher calorific value. Mr. Mathot informs us that some tests made with his producers have shown the following chemical composition and heat value compared to those of the ordinary type of suction producer:

	Ordinary Type	Mathot Producer
	%	%
CO_2	6	7
CO	23	24
H	15	22
N	52	46
B.t.u. per cubic foot	132	157

The ashpit being always open and the fire visible from the outside, supervision

and cleaning are possible at any time. The fire can be poked and the ash and clinker removed while the engine is at work without impairing the quality of the gas, since steam and air are always supplied in the same proportions.

In an ordinary producer a sudden dropping of incandescent matter in the water of the ashpit causes an increase of steam without a corresponding increase of air, with the consequence that an excess of hydrogen is put in the gas, which may cause difficulties at the engine. This does not take place with the Mathot producer because the air entering the ashpit is saturated with the superheated steam coming down the tubes *C* and any additional steam occasionally produced by clinkers dropping in the water escapes through the openings of the ashpit.

With almost all ordinary types of producer, when the engine slows down or the load drops suddenly, the rate of gasification does not decrease accordingly and an excess of gas may escape in the engine room. This does not take place with the producer under discussion, it is said, because any surplus of gas, being in contact with the air of the open ashpit, burns slowly as it escapes the fire without causing any explosion or smell.

Enriching Producer Gas

By Dow R. Walker

In my experience with gas engines, particularly producer-gas engines, I have often found engines struggling with too heavy loads, engines incapable of handling their rated loads because of poor gas, engines which because of their ignition arrangements would not operate properly on a slow-burning gas, and plants in which the load increased too suddenly for the producers to respond promptly to the demand.

For overcoming these difficulties I hit upon the expedient of introducing gasoline into the gas or air line close enough to the engine to be convenient for the operator and not so close as to give unequal distribution of gasoline to the cylinders. This has been tried on single-acting horizontal, tandem double-acting horizontal and multicylinder vertical engines of different makes, and it has proved highly satisfactory as a means for giving temporary relief.

In one instance, it was adopted permanently to enable a three-cylinder vertical engine to carry about 15 per cent. more load than it was able to carry on the gas supplied. It became imperative that this extra load should be taken care of, and if the engine could not handle it a motor would have to be installed. The engine had 14x14-in. cylinders and was rated at 135 hp. when running 275 r.p.m., but I doubt if it ever developed its rated horsepower.

The gasoline was introduced into the air line of the engine by means of the arrangement illustrated in Figs. 1 and 2. A nozzle was made by flattening and bending a piece of ¼-in. pipe of such a length that the opening came about to the center of the air pipe when the base of the nozzle was screwed into the reducing bushing, as shown in Fig. 1. A needle valve was inserted between the

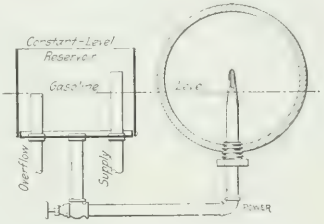


Fig. 1. Connection between Reservoir and Air Line

nozzle and a small constant-level reservoir from which gasoline was fed to the nozzle by gravity. The valve from a water gage does very well for a needle valve and a water bucket can be used as a temporary reservoir. Fig. 2 illustrates the shape of the nozzle. In setting the nozzle in the pipe, the opening should be turned in the direction of the flow of air or gas.

It was decided after the first experiment proved successful to install permanent apparatus to supply the gasoline; accordingly, a 100-gal. tank was buried underground outside the engine room, as shown in Fig. 3, and connected up to the overflow of the little reservoir and to a small pump which was driven by the engine at such a speed that it supplied more gasoline than the engine needed, and therefore kept the level constant at the top of the overflow pipe in the reservoir. The overflow pipe carried the surplus gasoline back to the underground tank and its upper end was so set that the level of the gasoline in the reservoir was just below the outlet of the nozzle. With this arrangement there is no danger of the air pipe becoming flooded with gasoline.

This apparatus was put into operation

Fig. 2. Shape of Nozzle

over a year ago and so far as I know it is still in use. The engine handled the full load with apparent ease.

In using such an arrangement it is advisable for the operator to set the needle valve open just enough to feed only the gasoline required for the excess load and to see that the producer is kept in full operation, in order that the engine may not use too much gasoline or even run on that alone; gasoline is much more expensive than producer gas.

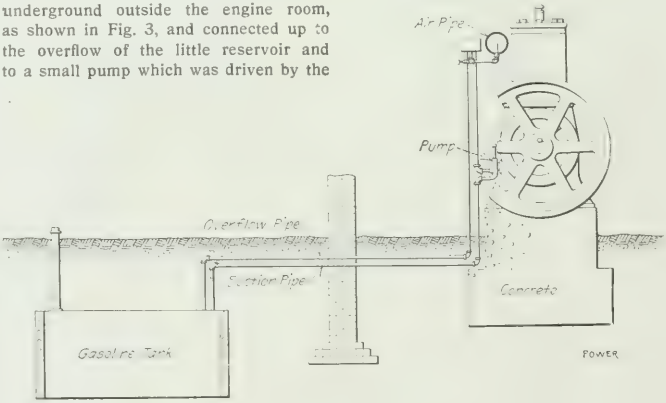


Fig. 3. Piping from Storage Tank to Engine

LETTERS

Improving the Magneto Drive

The magneto on one of my gas engines gave considerable trouble for some time after the engine was installed, and the remedy that I used to overcome the difficulty may be of benefit to someone else having trouble of the same kind. The magneto was driven by friction from the flywheel of the engine through a friction governor wheel on the armature shaft. The governor allowed the friction wheel to bear against the flywheel just hard enough to maintain the proper speed. If set in the intended operating position, the leather disks of the friction wheel would soon wear away until they failed to touch the flywheel of the engine, allowing the magneto to stop; and if pressed firmly against the flywheel, the speed of the magneto would be excessive, causing undue wear of the commutator and brushes.

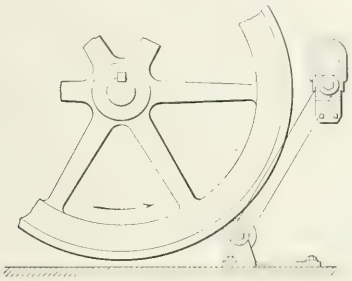


FIG. 1

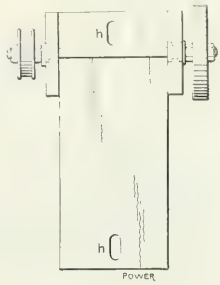


FIG. 2

I decided to try running the magneto with a belt and rigged up a small stand and countershaft on the floor as shown in Fig. 1, setting the magneto on a bracket on the wall with a 3x1-in. pulley substituted for the former friction governor wheel. Fig. 2 shows the plan of the countershaft and its stand on a larger scale.

The base and brackets of the stand were made from ⅞-in. pine lumber. A slot, *h*, was cut near each end of the base to take bolts; the heads of these bolts were fastened in the floor. The holes through the brackets for the shaft were bored to about ⅞ in. and counterbored to about 1 in. for a short distance at each end, filled with babbitt metal and this bored to ½ in., the size of the shaft. This construction, which is indicated by the dotted lines in Fig. 2, holds the babbitt from slipping endwise.

The shaft was made of a piece of ½-in. cold-rolled steel, threaded a short distance at each end. The pulleys were turned up from wooden blocks and fastened on the ends of the shaft by means of faced nuts and washers, one on each side of each pulley, as shown in the sketch.

The larger pulley was faced with leather by gluing a leather strip around it; the shaft and pulleys were then assembled, centered in the lathe and turned true.

This arrangement has been running 24 hours a day for several months and is giving excellent service with a minimum of attention. I have only renewed the brushes twice in this time instead of once every two weeks, as I did before the change was made.

EARL PAGETT.

Coffeyville, Kan.

A Broken Piston

A defect which put the piston of a gasoline-engine cylinder out of commission is shown in the accompanying sketch. The top packing ring of this piston is rather close to the end. Either from this cause or on account of a crack forced into the collar when the machining was done on the groove, a section *S* about 2 in. long broke out. This broken piece danced on top of the piston and was plugged through the top, as represented at *T*. The piston top was very thin, being less than ⅛ in. thick, and furnished the least resistance to the sharp plug of cast iron. The clearance allowed the plug to stand up about ¾ in., as shown.

THE PISTON

Fortunately, the cylinder head was strong enough not to be injured, but a new piston was necessary, of course. The incident proves that mechanical imperfections are yet with us, and — the consumer pays the bills.

B. F. WEBSTER.

Scranton, Penn.

Crankshaft and Belt Breakage

In the Dec. 26 issue, Howard S. Knowlton illustrates a fractured bolt in a connecting-rod big end and suggests two possible causes for the fracture. Whatever may have been the cause of the breakage of this particular bolt, it was *liable* to have been broken by the absence of fillets at the shoulders along its length. That is, of course, if the bolt was actually formed as indicated in the sketch. A gas-engine firm of world-wide repute had several failures of the connecting-rod bolts and crankshafts of its engines. It was finally decided that the cause of the fractures was, in the majority of cases, the sharp shoulders with which these parts were turned. The chief engineer issued orders to scrap all the bolts, and all the shafts for engines of under 16 hp., putting the forge and turnery on night shifts in order to replenish the stock with filleted bolts and shafts. This was about four years ago. Remarkably few failures of connecting-rod bolts or crankshafts have been reported in connection with this firm's engines since that date, and those which have occurred have been directly attributable to other causes, such as heavy premature ignitions and the like. The provision of fillets at sharp shoulders is not a matter requiring a great amount of skill, time or money and it is certainly an additional safeguard against fractures which every manufacturer of internal-combustion engines should adopt.

JOHN S. LEESL

Manchester, England.

In England steam engines furnish the bulk of our electric power in public electricity stations. A few Diesel oil engines are in use, mainly of very small size, and there are a few medium-sized gas engines. One or two stations have water power, but none of these have so far seriously challenged steam. In Germany things are different. It appears, states a contemporary, that of the public electricity works in Germany, 800,000 kw. is installed in exclusively steam stations, 400,000 kw. in gas stations, 250,000 kw. in water-power stations, and 400,000 kw. in combined water and steam stations. These figures are certainly remarkable when viewed in the light of the position in England.—*The Engineer.*

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

A High-potential Project for South Africa

According to press reports, a 150,000-volt transmission line 600 miles long is under serious consideration by the British South Africa Co. It is stated that a 50,000-hp. generating station is to be located at Victoria Falls, in Rhodesia, and the power transmitted to the Witwatersrand, 600 miles distant.

A pumping station is to be built on the Crocodile River about 500 miles from the falls and 100 miles from Johannesburg. There will be installed motor-driven pumps which, during periods of light loads, will be operated by the surplus power from the turbine station to store water in a large reservoir to be built on the adjacent hills. During periods of maximum demand auxiliary dynamos will be operated by this supply of stored-up energy to generate power.

Without such a scheme of alternate storage and regeneration much of the kinetic energy of the swiftly moving water at the falls would be wasted when the power demand is light, as it commonly is in hydraulic plants in California. This arrangement also permits the plant to be operated continuously at full load, which results in high efficiency.

To guard against interruptions of the system by shutdowns or other contingencies, it is proposed to build a 20,000-hp. auxiliary steam plant about 100 miles from Johannesburg.

Optimus Plating Dynamos

The accompanying engravings illustrate some constructional features and operating characteristics of the "Optimus" electroplating dynamo built by the Munning-Loeb Co., of Matawan, N. J.

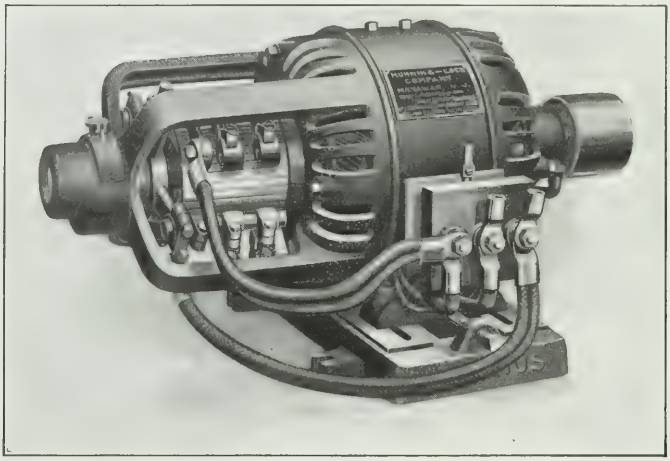


FIG. 1. OPTIMUS ELECTROPLATING DYNAMO

Fig. 1, giving a view of the complete machine, shows that the windings are protected from mechanical injury by a slotted housing at each end of the field-magnet yoke ring, which is unusual in plating machines, although quite common in generators built for lighting and power service. Another feature adapted from high-voltage practice is a composition brush applied to the commutator radially instead of at an angle approaching the tangent of the commutator circle. The brush is described as being compounded from carbon and graphite.

The method of attaching the brush-holder studs to the quadrant arms is a slight departure from common practice. Instead of bushing the hole in the arm with a short insulating tube flanking the arm with washers and following these with a collar and a nut, as indicated in Fig. 2 and generally practised, two insulating sleeves are used and these project considerably beyond the edges of the arm and no collar and nut are used on the brush stud, the latter being held by means of transverse bolts through lugs on the arm, the end of which is split in order to allow the bolts to clamp the "eye" on the insulating sleeves. This construction is illustrated in Fig. 3. It obviously reduces the cost of the studs and their insulation and increases the length of the leakage paths between the studs and the supporting arms.

The Optimus dynamos are compound-wound and very slightly overcompounded,

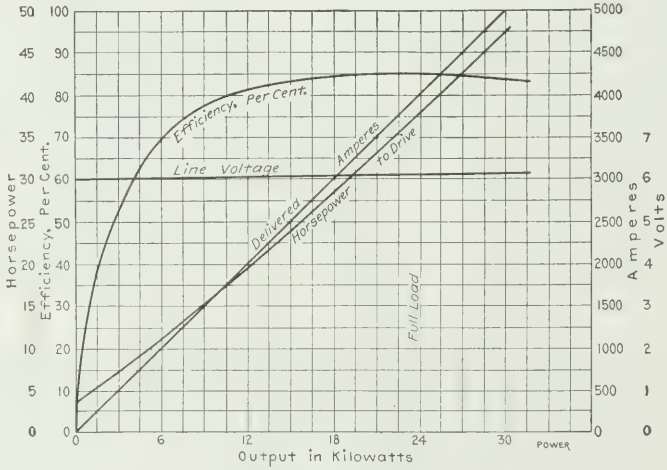


FIG. 4. PERFORMANCE CHART OF 24-KW. PLATER

as inspection of the voltage line in Fig. 4 will show; the electromotive force rises from 6 volts at no load to about

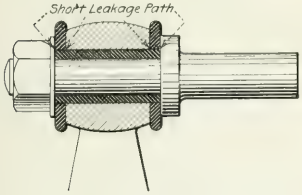


FIG. 2

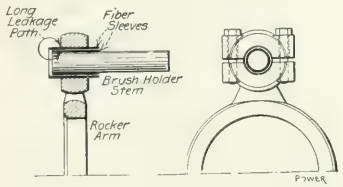


FIG. 3

6.1 volts at full load. This chart, we are informed, was plotted from the results of a test of a 4000-ampere machine.

LETTERS

Mr. Mc Ginnitie's Rattling Exciter

It is to be regretted that Mr. McGinnitie did not give more information concerning the rattling exciter mentioned in his letter in the Jan. 2 issue. Information as to the size, make, speed, voltage, number of poles, etc., would have made it less difficult to advise.

If the armature was not tried for balance on knife-edge bearings, it would be well to go over it again and make dead sure that it is in perfect balance. The smaller the machine and higher the speed, the more important it becomes to have perfect balance. The bearings must fit properly; that is, not only fit the armature shaft, but, if they are of the sleeve type, fit the bearing housings as well. This may be part of the trouble, as at light load the weight of the armature rests entirely on the bearings, while at heavy load there may be an unequal pull on the armature which lifts it momentarily in the bearings and starts the rattling. It would be well to examine the field-magnet coils to see that they are held firmly, and at the same time note if the magnet cores are tight against the yoke.

If the machine is large enough to have several ventilating ducts in the armature core, these should be examined very carefully to see that they are not loose. The plates on the ends of the armature core should be examined also. See that all armature coils are firm in the slots. Test the drop across each field-magnet coil at all loads and see if the drop for each coil is the same. If the machine is a four-pole one and the armature spider has three arms, and the design of the machine is such that the armature core is worked at too high a flux density, the machine may be out of magnetic balance. It is assumed, of course, that the airgap is the same for each pole.

The belt is an important factor in such cases; it should not be allowed to flap, as once oscillation is started it is continually magnified.

I believe that if Mr. McGinnitie will examine the points mentioned he will find a solution to his trouble, although it is just a little puzzling as to what is meant by rattling; there must be some particular spot that rattles, and not the whole machine.

I remember being called upon to locate a rattle in a 500-kilovolt-ampere alternator; after wedging one lamination tooth in the stator core, the machine ran as usual.

L. EARLE BROWNE.

Roundup, Mont.

A Bad Start

I had occasion recently to connect up and start a 20-kw. dynamo which had been set in position before I arrived. After I had made the connections with the switchboard I put the belt on the dynamo and started up; within a few minutes the bearing nearest the pulley began to get hot and the machine to drag. As the bearings were ring-oiled and I had filled the oil wells myself and oiled the shaft before starting and after, I knew that the trouble could not be lack of oil, so I decided to take down the bearing and examine it. The journal box was fitted with a babbitt-lined sleeve held in place by a setscrew. After taking out the setscrew and taking off the journal bracket of the machine, I had to use a jackscrew and chain to get the box off the shaft. When I got it off I found in it a lot of iron borings, many of which, on starting up, had worked onto the babbitt and seized the shaft. After scraping the sleeve and the shaft and cleaning the chips out of the box, the machine gave no trouble.

The dynamo room adjoined a machine shop, and I do not know whether the iron chips were left in carelessly by the man who assembled the machine or whether someone did the trick for spite work. However that may be, I decided that the safest way is to take down and examine the bearings on any new machine, and I shall do that with any that may have to be set up in future, whether it has been examined by anyone else or not.

ALLAN A. BLANCHARD.

Ocala, Fla.

Demagnetizing a Watch

My watch was so badly magnetized that it gained one-half an hour in two hours and would pull a compass needle clear around. I took it to a man who took the magnetism out of it very effectively. He hardly gave me a chance to see his apparatus, but from what little I did see, it seemed to be a simple solenoid or coil supplied with alternating current from the lighting system. He lowered the watch into the center of the coil and moved it slowly up and down.

I do not remember reading anything on how to take magnetism out of watches (you could hardly take it out by heating and hammering them), and as the information would come in useful at some time to some of us, I would suggest that some of the readers who know how to do the trick might give us the benefit of their knowledge through the columns of POWER.

S. G. ROSE.

Brockville, Ont.

[Mr. Rose's surmise that the apparatus used in his case was a solenoid excited with alternating current is undoubtedly correct. Such a coil can readily be made by winding about ¾ lb. of No. 27 double silk-covered wire on a spool 4 in. long with a 2½-in. hole through the center. This may be excited from an ordinary 110-volt lighting circuit carrying alternating current at 60 cycles.—EDITOR.]

Fluctuating Field-Coil Voltage

While measuring the resistance of the shunt field winding of a railway generator by the "drop" method a few days ago, I observed a very peculiar phenomenon. The ammeter in the field circuit read 5 amperes, perfectly steady; the potential at the field terminals was 550 volts and this also was perfectly steady. The voltage across any one field-magnet coil, however, swung violently from about 30 to 70 volts when it should have been about 50 volts steady. I noticed that the fluctuations were exactly in synchronism with the strokes of the engine to which the generator was direct-connected. Subsequent investigation showed that the armature was revolving eccentrically with respect to the pole-face bore. This caused a varying magnetic circuit and a consequent rise and fall of induced voltage in response to the changes of magnetism. The fact that the total voltage across the shunt field winding was constant seems at first to be impossible, but that is as it should be.

F. OPPENHEIMER.

Baltimore, Md.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Steam Heating Large Department Stores*

By Davis S. Boyden

A few years ago one of the largest department stores in Boston had commenced the erection of a new building which would about double its floor area. Up to this time the store had operated its own isolated electric plant, and plans for a new plant were under way. It was then brought to the attention of those in charge that central-station electric service would save the large investment and a considerable amount on the operating costs of an isolated plant.

The operating costs of the proposed plant and the cost of central-station service combined with the operating of a steam-heating plant were threshed out among several of the best engineers, each one furnishing his own estimates. These estimates on the plant costs and on the electric consumption varied somewhat, but when it came to the cost of operating the boilers for steam heating only, there was a wide difference in the estimates and all were much above the figure of the central-station people for operating the heating plant. This wide variation only shows the great lack of information on the subject of steam heating and the fact that its relation to the electric requirement is most generally overestimated. The central-station people received a long-term contract for the electric service, and the actual cost of operating the steam-heating plant during the past two years has fallen well within the estimate made by the engineers of the central-station company.

The department store occupies three large buildings, the old store having a floor area of 273,400 sq.ft., the Francis Building, 69,400 sq.ft. of area, and the Avon Street Building, 295,000 sq.ft., making a total floor area of about 637,800 sq.ft. The Avon Street and Francis Buildings adjoin each other and a tunnel under the street connects these buildings with the old store. The old store consists of a number of adjoining brick and stone buildings of varying architecture from four to seven stories high, with basement. The Avon Street Building is of steel construction, terra-cotta finish, nine stories high, with basement and subbasement. The Francis Building is also of steel construction, brick finish, eight stories high. The accompanying plan shows the arrangement of the buildings and surroundings.

Steam is furnished from the three 250-hp. Babcock & Wilcox boilers located in the sub-basement of the Avon Street Building. These boilers are hand fired and have projecting furnaces of the so called dutch-oven type. The boilers are operated only during the heating season, live steam for the small summer requirement being furnished through a steam main from the boilers in a neighboring building.

The steam-heating system of the old store is of the direct-pressure type, with the exception of the basement, which has an indirect system of heating with forced ventilation. Hand control is used throughout this building, the returns being trapped to the receiver in the boiler room.

The new Avon Street Building and the Francis Building have indirect heating on the first floor as well as the basement, this heating being automatically regulated by Johnson thermostats. The direct radiation on the upper floors is fitted with the D. G. C. automatic return valves, which discharge the condensation direct to the open receiver. The pressure carried on the direct radiation varies from 3 to 6 lb., according to the weather.

The radiation surface and other data regarding heating are given in the accompanying table.

TABLE 1. DATA OF THE THREE HEATING PLANTS

	Outside Volume, Including Basement, Cu.Ft.	Exposed Wall Surface, Sq.Ft.	Exposed Glass Surface, Sq.Ft.	Mechanical Ventilation, Cu.Ft. Fresh Air per Minute	Direct Radiation, Sq.Ft.	Indirect Radiation, Sq.Ft.
Old store	3,706,700	50,353	17,251	40,000	8,122	1,936
Avon Street Building	3,836,000	28,030	26,519	68,000	11,595	4,182
Francis Building	848,300	16,541	7,129		4,368	
Totals	8,391,000	94,924	50,899	108,000	24,085	6,118

Test of the Heating Plant

In order to study the daily load curve of the steam-heating plant as compared with the electric-load curve and also to determine the efficiency of the boilers, a two days' test was made on the heating plant.

A number of thermometers were placed throughout the buildings and readings taken hourly at two points on the first and third floors and at one point on the fifth floor of the old store, and at one point on the first, third, fifth and seventh floors of the Avon Street and Francis Buildings. Temperatures were also taken on the roof of the old store and the Francis Buildings while the store was open and access could be had to the roof. The outdoor temperature was taken hourly in Bedford St., near the boiler-room door.

On the boiler test, the amount of steam used for heating is considered to be the total water fed to the boilers and this is true except for steam used by the boiler-feed pump and the small amount used in the kitchen and for hot water. The feed water was measured by a hot-water meter connected in the feed line. Hourly readings were taken on this meter, care being used to keep a constant water level in the boiler. The coal burned during the test was weighed out in 500-lb. lots as fired, but no attempt was made to keep a record of the coal burned each hour, this being affected by any change in thickness of the fire. Other readings taken in connection with the boiler test were feed-water temperatures, boiler pressures and pressures in the lines to the buildings, all taken at 15-min. intervals.

Calibration tests were made on the hot-water meter after using and a plot of corrections made. The meter was found to read about 4 per cent. low for flows of 2.5 cu.ft. per minute and greater. For less than 2.5 cu.ft. per minute, the error increased to as much as 15 per cent. low at 1 cu.ft. per minute, although this should be expected when the meter is designed for measuring a much greater capacity. The corrections from the calibration curve were then applied to the readings of the hot-water meter. The results of the boiler test were as given in Table 2.

TABLE 2. BOILER TEST

Duration of run, hr	48
Total water evaporated, lb	429,800
Total coal burned, lb	47,803
Boiler pressure, lb	77.5
Feed-water temperature, deg. F.	211.8
Water per lb. coal, actual, lb.	8.98
Water per lb. from and at 212 deg., lb.	9.30
Boiler horsepower	268.3

*Paper read before the American Society of Heating and Ventilating Engineers, New York City, Jan. 25.

AVERAGE PRESSURES ON HEATING LINES

1—Intermediate pressure line, lb	33.7
2—New store, direct radiation, lb	4.03
3—Old store, direct and indirect radiation, lb	3.46
4—Francis Building, direct radiation, lb.	1.04

The temperatures at different points in the buildings did not vary widely at any time, and the average for the whole store is used in the plot, Fig. 3. The top curve shows how the average inside temperature varies throughout the day. The temperature falls to 67 deg. during the early morning hours, rising to 70 deg. as the Christmas crowds invade the store. A maximum of 71 deg. is reached when the store closes, the building gradually cooling off again to 67 deg. during the night.

The second curve shows the changes is due to the shutting down of the fans.

To show the close relation between the coal burned each month for heating and the average outside temperature, the plot given in Fig. 2 has been made. As these quantities vary inversely, the solid line representing coal burned has been plotted to read up and the dotted line of average temperatures to read down. The slight variation in the form of these curves during the heating season is due somewhat to outside influences, such as wind and humidity, but principally to the lack of control of the hand-operated radiator valves. Similar curves for buildings having thermostatic control of the heating conform much more closely with one another. If 65-deg. average tem-

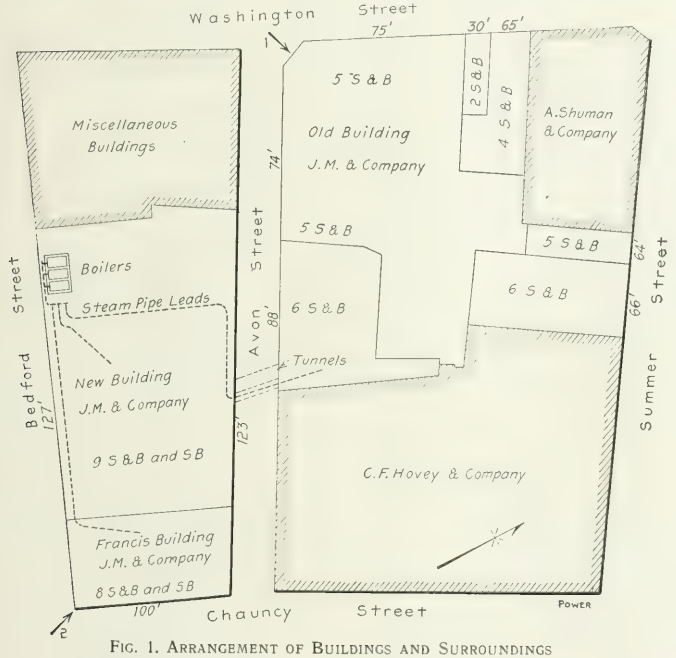


FIG. 1. ARRANGEMENT OF BUILDINGS AND SURROUNDINGS

of outside temperature on this day, which is typical of a December day during settled weather.

The bottom curve represents the coal burned that day, apportioned according to the boiler feed-water meter readings. The rise in this curve from 1 a.m. to 4 a.m. is due to the turning on of steam in the Avon Street Building, which had been turned off since 6 o'clock the night before. The more pronounced rise between 5 and 6 a.m. was caused by the turning on of steam and the opening of the air cocks in the radiators in the old store. The third rise at 8:30 a.m. is due to the starting up of the fans of the indirect-heating system. The gradual increase in steam after 3 p.m. follows the setting sun and the drop at 6 o'clock

perature is used to represent zero coal demand, a much closer coördination of results is obtained.

Electric power and light are furnished from the central station, the standard recording wattmeter accurately measuring the electric consumption. An automatic tape device is also connected with the wattmeters to record the exact consumption throughout the day and these records are on file for reference. The present electrical connected load is as follows:

	Kw.
Incandescent lamps	1998
Arc lamps	653
Iron and electric heaters	6
Elevator motors, 689	514
Other motors, 287	236
Total connected load	3407

The highest demand which has yet been recorded is 1054 kw., which is 31 per cent. of the connected load. This is of considerable interest, because in the case of an isolated plant the generator capacity installed would be from 50 to 70 per cent. of the connected load, not allowing for spare units, when less than one-third of the connected load is the maximum which is used for any half hour. The yearly load factor figured on a 24-hr. basis throughout the year is also of considerable interest to the engineer estimating on the electric consumption of this class of building. The load factor, or the ratio of the average consumption to the maximum, is only 30 per cent. The ratio of the average consumption to the total connected load is therefore

$$31\ (per\ cent.) \times 30\ (per\ cent.) = 9.3\ (per\ cent.)$$

As all the necessary data are now at hand for the consideration of the operation of an isolated electric plant, this phase of the subject will be considered.

The proposed plant, which was not installed, was to have tandem-compound noncondensing engines, which were estimated to generate 1 kw.-hr. on 5 lb. of coal, the exhaust steam being passed through a feed-water heater. The hourly electric consumption for Dec. 20 may then be multiplied by 5 lb. of coal and this plotted as the additional coal required to supply the electric service. The lack of coördination of the two loads is very evident from the plot, Fig. 2, a considerable amount of live steam being used during the night for heating, and by far the greater part of the exhaust from the plant being wasted during the day and evening.

The actual coal burned for heating on this day was 24,000 lb. The electrical consumption for this day would require 60,485 lb. of coal. If the same standard of heating is maintained with the isolated plant as with the heating plant, an additional amount of live steam will be required between the hours of 2 and 8 a.m. This live steam will be equivalent to 4250 lb. of coal, or 17.7 per cent. of the total coal for heating. The total coal used by the isolated plant will be 64,735 lb. The percentage of exhaust from the plant which may be used for heating will then amount to 32.6 per cent. for this particular day.

Assume that this is a fairly average day for the heating season, there being colder and warmer weather when more or less live steam would be required. The total coal used for steam heating during the past 12 months was 1921 tons. Assume that 17.7 per cent. of this would have been live steam from the isolated plant, leaving 1580 tons as the portion of the year's coal which might have been furnished from the plant exhaust. The electric current consumed during the

past year, if the same were generated at an isolated plant, would require 6941 tons of coal, figured at 5 lb. per kilowatt-hour. The portion of this exhaust steam which would be used for heating will be

$$1580 \div 6941 = 23 \text{ per cent.}$$

the remaining 77 per cent. of the steam being used noncondensing with poor economy.

The total cost for operating the heating plant for the year ending Nov. 30, 1911, was $8582.29, during which period 2,776,370 kw.-hr. of electricity were used on the premises. Dividing the cost of heating by the kilowatt-hour use, it is found that the cost of heating is equivalent to 3.0909 mills per kilowatt-hour used. Should a reduction be made of the cost of coal required to furnish the live steam for heating, which is 0.5471 mill per kilowatt-hour use of electricity, the total value of the exhaust steam per kilowatt-hour would be 2.5438 mills.

Electric Heating in Norway

Initial steps are being taken in Stovanger, Norway, writes U. S. Consul P. Emerson Taylor from that city, for the installation of a system of electric heating. A few firms are already heating their establishments by electricity, and have purchased and installed German apparatus and fixtures for that purpose.

The board of directors of the city electric-light plant has asked that the city council give it full power to make all contracts with firms desiring to install electric heating and has transmitted to it the application of one of the larger firms for the use of 100 hp. from the city plant for heating purposes.

The contracts proposed by the directors of the light and power plant, if approved by the council, provide for the sale of power for heating to firms and individuals for a period of five years, with the option on the part of the purchasing firm or individual to extend the contract for another five years, the city to have the right to change or cancel the contract any time after the first five years, should it be necessary, upon giving one year's notice. The contracts further provide that between 4 and 7 p.m. during the winter season when the maximum light power is required the city may, if necessary, restrict the firms to an amount below the maximum named in their contracts.

Many of the factories will use electric current both day and night for heating, and the cost will therefore be very reasonable. As so much of the city's available power goes to waste or is unused except between the hours of 4 and 7 p.m., both the city and the prospective purchasers of current for heating look forward to the installation as an economical proposition.

While the price for electric power for heating has not been definitely determined by the council, the price proposed by the directors is 25 crowns ($6.70) per horsepower per year, and this will in all probability be the rate.

The present capacity of the city electric plant is 8000 hp. Of this amount 4800 hp. is now in use, about one-third being employed for light and two-thirds for factory power. The city, which has a population of 38,000, is constantly installing additional lights and selling additional power to the factories. Although the capacity of the present electric plant is only 8000 hp., the city owns, in addition to the waterfalls used for the power of the present plant, two other waterfalls, and by connecting with these and enlarging the plant it will be able to furnish 25,000 hp.

By the plans and contracts proposed the city will merely sell the power to the firms and individuals desiring to use it, the purchasers themselves installing the heating apparatus.

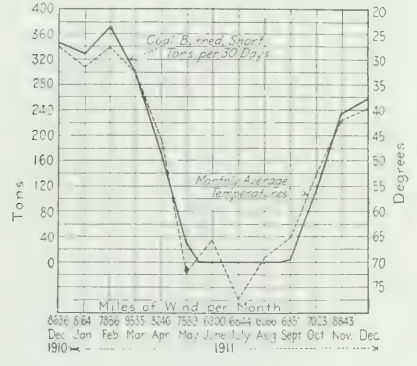

Tons
Degrees
Coal Burned Short Tons per 30 Days
Monthly Average Temperatures
Miles of Wind per Month
8636 8647 7856 9535 8246 7582 6200 6644 6100 6351 7023 8843
Dec Jan Feb Mar Apr May June July Aug Sept Oct Nov. Dec
1910
1911

FIG. 2. RELATION BETWEEN COAL BURNED FOR HEATING AND AVERAGE MONTHLY TEMPERATURES

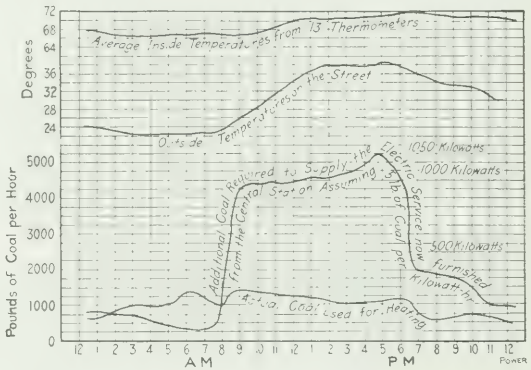


FIG. 3. RESULTS OF TESTS MADE DEC. 20, 1911

TABLE 3. ITEMIZED COST OF HEATING WITH EQUIVALENT COST PER KILOWATT-HOUR USE OF ELECTRICITY

Item	Cost for Year Ending Nov. 30, 1911	Mills per Kw.-hr. Use
Miscellaneous expense	$122.84	0.0442
Fuel	5718.14	2.0596
Water	229.94	0.0828
Oil and waste	7.35	0.0026
Labor	2331.44	0.8391
Repairs to mechanical appliances	38.20	0.0138
Repairs to boilers	134.38	0.0488
	$8582.29	3.0909

It may be a ready means of comparison to append the deductions in Table 4.

TABLE 4. THE RELATIVE COST OF STEAM AND ELECTRIC SERVICE PER CU.FT. OF SPACE AND PER SQ.FT. OF FLOOR AREA

	Cost per Cu.Ft. of Volume	Cost per Sq.Ft. of Floor Area
Steam	$0.00102	$0.01345
Electric	0.00641	0.08436
Total	$0.00743	$0.09781

Charge for Steam Heat

I am in charge of a 300-hp. plant in a hotel and will soon be obliged to furnish some steam for heating. I would like to hear from readers of POWER as to what unit I should adopt for measuring it and what rate should be charged.

C. E. DIAMOND.

Stockton, Calif.

Nearly 500 lantern slides on steam turbines, governors, valve-setting and various power-plant and technical subjects will be lent by the Institute of Operating Engineers to organizers and others in connection with its educational work. The use of these slides has been made possible through the courtesy of Frank Martin, Willis Lawrence, Asa P. Hyde and Hubert E. Collins. A list of slides may be obtained on application to the secretary of the institute.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

New York City's Coal Problem

Elsewhere in this issue is an outline of the procedure adopted by the Department of Water Supply, Gas and Electricity of New York City regarding the purchase of coal for the numerous pumping stations coming under its supervision. When these specifications were first put into effect, about two years ago, they met with strong opposition from certain quarters. It was claimed that they would impose an unnecessary hardship upon the coal dealers; that the latter would raise the price to protect themselves against penalties; that competition in bidding would be lessened; and that the city would be the ultimate loser.

Whether any of these or other similar predictions have come true matters little, although it might be mentioned that the penalties have been surprisingly small. The all important fact remains that the city is now receiving a better quality of coal than formerly and that during the first year of buying coal under the new specifications a saving of over one hundred and twenty-two thousand dollars was effected in the coal bill of this one department. In the various bureaus under the jurisdiction of the president of Manhattan Borough, which employ specifications similar to those of the Department of Water Supply, Gas and Electricity, a proportionate saving was effected.

In fairness to those largely responsible for the saving, it may be said that the whole credit for it should not be given to the specifications. A large part of it was brought about by giving special attention to individual cases, changing furnaces and grates to burn certain coals economically, and, in short, applying scientific principles to combustion.

Unfortunately, the administration of a large city is cumbersome and necessarily involves much of the so called "red tape" which is plainly evident in the procedure as outlined. In this connection it would be interesting to know how much it actually cost the city for the services of experts and inspectors to enforce the specifications. Of course, in order to arrive at the actual saving in dollars and cents it would be necessary to deduct this additional expense from the apparent saving. Perhaps those in a position to compile this information will enlighten us.

However, we believe the city has made a good start in the handling of its coal problem and will doubtless make certain modifications tending toward simplicity as the conditions warrant.

The British Thermal Unit

Reginald Pelham Bolton, at the recent meeting of the American Society of Heating and Ventilating Engineers, of which he is the retiring president, submitted a plea for the abandonment of the use of the term "British thermal unit" in favor of the more simple expression "heat unit" for the unit quantity of heat.

It would seem to make little difference whether this quantity were called a "heat unit" or a "thermal unit," except that the former is less pedantic and the latter accords with the German *Warme-einheit.* A single word, as the French have in *calorie,* would be better than either. The adjective British was presumably attached to distinguish the English from the Continental or metric unit. British is wider than English politically and geographically, but narrower where language and customs are concerned. For Great Britain itself, the abbreviation B.t.u. has the disadvantage that it is identical with the much used abbreviation of the Board of Trade unit of electric energy, the kilowatt-hour.

Of greater importance, however, than the changing of the name is the definite determination of the significance of the name; the positive definition of the quantity to which the name applies. The tyro learns that the unit by which quantities of heat are measured in the English system—call it the B.t.u. or what you will—is that amount of heat necessary to raise one pound of water one degree Fahrenheit, and he is satisfied and happy—until

he learns that the specific heat of water varies with the temperature, that it takes more heat to raise the temperature of a pound of water one degree starting from one temperature than it does starting from another. And then he learns that some authorities consider the heat unit as that amount of heat required to raise the temperature of a pound of water one degree from the freezing point, others from its point of maximum density about 39 deg.; others from 62 to 63 deg., because this is about the temperature of the room in which experiments are supposed to be made, and others still, the average heat per degree rise in temperature between 32 and 212.

The difference is not great enough to be of importance in ordinary work, but there should be a clear conception of the basis of so important a physical unit and its name, when adopted, should mean something definite. Uniformity of usage and precision of statement are the ends which should be sought.

The Manhole Frame

In the tests to destruction of two return-tubular boilers, twenty-seven years old, recently conducted by James E. Howard and reported in the Dec. 5 issue of POWER, the cast-iron manhole frame failed under a hydrostatic pressure of 270 pounds. Similar tests at Ishpeming, Mich., on three boilers thirty years old are described on other pages of this issue, and in each case failure occurred at the manhole.

On two of the boilers the frame broke at pressures of 260 and 275 pounds respectively. On the other boiler the manhole frame had been replaced with a patch and at 300 pounds pressure thirteen of the patch bolts sheared. Subsequent tests of the metal showed that the boilers were as good as the day they were made, and omitting the fact that the rivet holes had not been reamed, the workmanship appeared to have been excellent. In no way had the boilers deteriorated in the long service to which they had been subjected.

Eighty pounds had been allowed as the working pressure of these boilers, and with failure at 260 pounds it is evident that the factor of safety of the manhole frame was only 3.25, and, therefore, considerably below that usually specified. Evidently the design of this frame is at fault, and more particularly the material of which it is constructed.

The stress developed at the side of the manhole, due largely to the rigidity of the frame, was, of course, excessive, but at best cast iron is poor material to use in boiler construction and for high-pressure work should not be tolerated.

What a Piece of Waste Can Do

Nothing is more innocent-looking than a piece of clean, white waste; nine-tenths of the operating engineers have some of it in their jumper pockets and the other tenth will have a bit in their hands. But, notwithstanding its harmless appearance, it is dangerous unless kept in its proper place, used for legitimate purposes and properly cared for when it becomes oil-soaked and dirty.

Mysterious fires have had their origin in a piece of dirty, oily waste thrown into a corner by some careless person, and then when spontaneous combustion takes place people wonder what caused the fire.

It is not unusual to find that an oily waste can, such as is provided in factories, contains nothing but the ashes of charred waste; particularly is this noticeable after a shop has been shut down for a few weeks. Someone neglected to empty the waste can and the property was consequently jeopardized.

Waste left in a boiler has been the direct cause of bagged plates. The heavy particles of foreign matter precipitated from the water when the boiler was under steam pressure gathered on the piece of waste and, settling on the fire sheet, caused it to overheat and develop a bag which necessitated more or less extensive repairs.

Not long ago we published an account of an engine wreck in which the engineer lost his life. The cause was a harmless-looking piece of waste which was found tightly wedged between the gears of the governor. This permitted the engine to run at such a speed as to disrupt the flywheel, which caused the engineer's death.

The neglect of apparently trivial conditions often results in serious accidents. Safety in small matters is frequently as important as are those of greater moment. Often the results due to the condition of small details will result as disastrously as those occasioned by neglect of the greater ones.

There were twenty-seven boiler explosions in the United States and Canada during November, and they caused nine deaths. In October there were thirty-five explosions and fifteen persons killed. A steam boiler is more dangerous than dynamite in the hands of incompetent persons. Perhaps an investigation of the causes of these accidents would show a high percentage of incompetency and careless operation.

The wage question in this country has a modicum of consolation when we consider the recent letters on power-plant wages in China, and that an English farmhand gets $126.53 a year, "with house and potatoes, when his wife assists him."

A New York surgeon was sued by a man who claimed that the doctor neglected to remove an instrument after an abdominal operation. This reminds us of the careless fireman who left a hammer in a boiler after cleaning it. Either "boiler" might have been damaged beyond repair.

"Let us be a mother to you," is the entreaty of an advertiser in the *Rose Technic*. We are too old for anything like that, but if anyone will father a good operating kink or act as "assister" in making POWER an even better paper than it now is, we will gladly meet him more than half way.

James Watt was worried by a man who claimed to be able to evaporate a hogshead of water with an ounce of coal. Had the chemical compound faker gotten to work so soon?

Two boiler explosions in New York City and nobody killed, but look out; there is an old saying that the third time never fails.

The endeavors of Dr. Duncan, of the University of Kansas, and other scientists to make petroleum edible should help to pour oil on the troubled waters of the high cost of living.

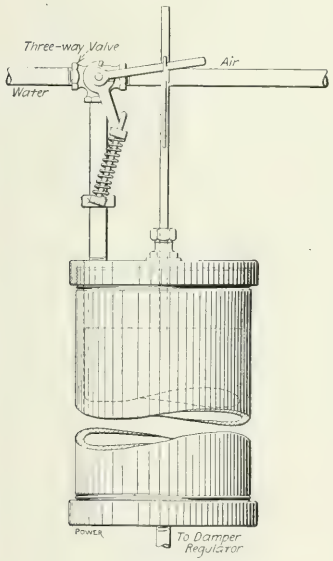
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Air Operated Damper Regulator

The accompanying sketch illustrates an apparatus for operating a damper regulator in plants where the water pressure is not sufficient to operate a damper regulator, but which have a compressed air supply.

The tank is made out of a steam pipe with a cast-iron cap screwed on each end. I use a three-way valve, one side running to the water pipe, the other end to the air supply and the third to the tank;



DETAILS OF WATER CONTROL

a lever is attached to the three-way valve operated beyond the center by a loose lever which is moved by a float-rod and thrown quickly by means of the coil spring after passing the center. It operates alike in both directions. When the valve is thrown to the water inlet a port is open to the air, thus relieving the air pressure on the tank and letting the water in. When the tank is full, the valve is thrown, shutting off water and admitting air pressure on the water.

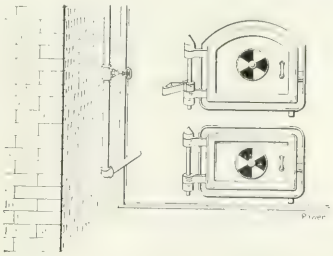
I use 80 lb. air pressure. A pipe leads from the bottom of the tank to the damper regulator.

W. I. CRAWFORD.

St. Louis, Mo.

Triangle Door Buffer

The accompanying illustration shows a triangle hung on the rod that carries the furnace door on a boiler front and is for the purpose of keeping the door from swinging too far back. In our case



DOOR BUFFER FOR FURNACE DOOR

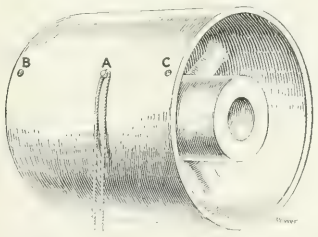
the drain pipe from the water column was run down a wall, but in the way of the door. The triangle was used to protect the pipe.

THOMAS O'CONOR.

Golden, Colo.

Cord Pulley Lagging

To cover a pulley cheaply and quickly, drill a small hole about $\frac{1}{16}$ in. in diameter in the face as at *A* and drive in a small pin and cut off about $\frac{1}{8}$ in. above the pulley face; then obtain a continuous hard, twisted cotton cord $\frac{1}{8}$ in. in diameter and free from knots, and loop the middle point of the cord over the pin. With the free ends held tight,



PULLEY ABOUT TO BE LAGGED WITH CORD

turn the pulley in the direction of rotation, applying a good coat of belt glue as the cord is wound on the pulley. When the face of the pulley is completely covered, draw the free ends through the holes marked *B* and *C* on the sides and fasten with a soft wooden pin well covered with glue. As soon as the glue hardens, the pulley will be ready for use.

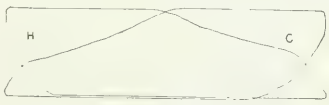
The pulley surface should be thoroughly cleaned before applying the glue. As the cord forms a right- and left-hand thread, so to speak, the belt will tend to work from the side to the center, which will insure the belt running on the center of the pulley. The length of cord for one turn may be found approximately by multiplying the diameter of the pulley by $3\frac{1}{7}$, and this multiplied by the number of turns necessary to cover the face will give the total length. This pulley cover is easily cleaned and will last a long time.

D. H. HULL.

Asylum, Miss.

Diagrams from Three Cylinder Compound Engine

The accompanying diagrams were taken during the past season from the engines of the Morton line steamship "City of Benton Harbor," plying between Chicago and St. Joe, Mich. They should be of special interest to those en-



High-Pressure Diagrams

Port Low-Pressure Diagrams

Starboard Low-Pressure Diagrams

gineers who are not familiar with the three-cylinder compound type of engine.

The starboard low-pressure diagram is of more than passing interest as it introduces a phase of indicating not often met with in everyday practice and of educational value to beginners in the study of engineering science.

The feature of interest in this diagram is the peculiar steam line as indicated by the hump *abcd*. When I removed the card from the paper barrel of the indicator it caused me considerable surprise, for I had expected to see diagrams similar to the port low-pressure diagrams. The chief engineer, who was familiar with this eccentricity of his engine, assured me that the diagram was as it should be and the test was completed.

The "City of Benton Harbor" was built for the Graham & Morton line at the Craig shipyards at Toledo, Ohio. The installation of this type of engine was due to the desire of the ship's architect to avoid the cumbersome beam type of engine for side-wheel propulsion. The engines are at an angle of approximately 22 deg. to the keel. The cylinders are high-pressure, 38 in. in diameter, both low-pressure, 55 in., and the stroke is 78 in. The maximum speed of the engine is 42 r.p.m. and the boiler pressure is 145 lb., gage.

The high-pressure diagram is an excellent example of engine performance for this type of prime mover. Each low-pressure cylinder is served by an independent jet condenser. This explains the differences in vacuum shown by the exhaust lines of the diagrams.

The marked differences in the steam lines of the two low-pressure diagrams are explained by the fact that at a certain crank position both low-pressure cylinders take steam for a period dependent upon the cutoff and position of the valve-gear of the port low-pressure cylinder. Referring to the diagram, it will be seen that both low-pressure cylinders are taking steam from the admission line *e* to the point *a* at which the cutoff takes place in the port cylinder. Then, the receiver pressure increases as the starboard piston advances in its travel until the maximum pressure is reached at *b*. This pressure is constant until the piston has reached *c*, when a noticeable drop in pressure begins. The cutoff is approximately at *d*.

JAMES B. ROGERS.

Chicago, Ill.

Repaired Pump Piston Rod

When I took charge of my present plant the water end of the brass piston rod of the boiler-feed pump was so badly worn and scored that I could not keep it tight nor enough water in the boiler when the engine was working hard.

I filed the rod smaller at the worn part and fitted a tin ferrule over the rod and ran the cavity full of hard solder. By keeping the rod packed with soft packing, liberally supplied with graphite, it gave good service for some months.

A. W. CARD.

Glenboro, Can.

Repaired Broken Pump Cylinder

A small boiler-feed pump that was left without draining became frozen one cold night and the water cylinder head was forced out of the cylinder. The head on this pump was screwed into the cylinder like a plug; therefore when the head came off, it took some of the cylinder with it, as shown at *A*.

I cut off the broken portions and chipped out the threads remaining in the cylinder so that the head would fit in without screwing. Two holes were next tapped in the valve-chest, into which two studs were screwed. A yoke *B* was made to fit behind the projection where the drain cock screwed in. The head was replaced in the cylinder, the openings were filled with Smooth-On, and I put two straps across from the studs to the yoke; then I put on the burrs, and tightened the nuts.

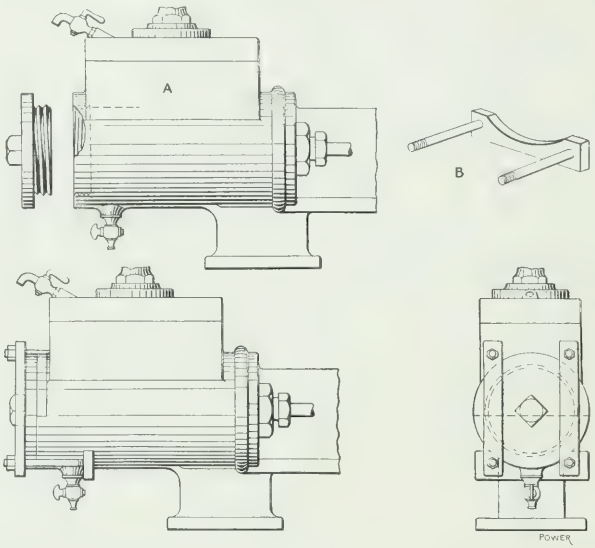
J. L. DONOVAN.

Vancouver, Wash.

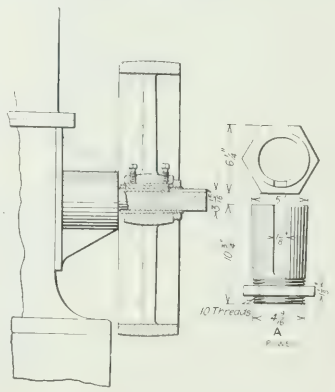
The Flywheel Bushed

The company I work for has a 12x11-in., single-acting, double-cylinder, upright engine, driving two 20-kw. generators; the engines run 285 r.p.m. Considerable trouble has been experienced lately because the setscrews of the two flywheels work loose. On one occasion it was only by sheer luck that the engineer in charge noticed that one of the wheels had worked loose and was about ready to plunge off of the shaft when he stopped the engine.

A taper bushing was made with the dimensions shown in the illustration *A*, and a slot ⅛ in. larger than the key of the wheel. The smaller end of the bushing was threaded with 10 threads to the inch for a nut—a coarser thread could not be used on account of the thin walls of the bushing; also, the fine thread will not allow the nut to work loose as easily as a coarse thread. The flywheels were then removed, the bushing slipped onto the shaft (the bushing being bored out to a size so as to slip onto the shaft without driving), and the flywheels put in place on the bushing; then the nut was screwed in and drawn up as tight



DETAILS OF THE REPAIR JOB



BUSHED FLYWHEEL

as possible. The wheels having been bored to the same taper of the bushings on account of the fine thread, the wedging action was very powerful.

After the engine had run for two or three days the nut was tightened again, and for the past six months nothing has been done to the bushings and there are no signs of the wheel being loose on the shaft.

V. T. KROPIDLOWSKI.

Winona, Minn.

Indicator Cords Responsible for Diagrams

The mechanical engineers had attached the indicator and taken some friction diagrams leaving their indicators to get some load diagrams later. During their absence I got busy, and after taking a few, I obtained the diagram shown in Fig. 1. It puzzled me for a time until I noticed the diagram was close to the end of the card, and on examining the indicator, I found that the cord was too long, and the drum striking the stop had caused the short compression line. I put a couple of knots in the cord and obtained the compression diagram shown in Fig. 2, which brought the compression very nearly the same at both ends of the cylinder. This diagram was obtained by lifting the latch on the steam gear and so preventing the steam from entering the cylinder, and then the diagram shown in Fig. 3 was taken.

The rounding corner of the diagram at the point of cutoff is partially accounted for by a worn corner on the tripping lever.

The engine has an 18x42-in. cylinder fitted with double-ported Corliss valves.

As the mechanical engineers did not return, I inquired if they had noticed any difference in the diagrams, and I shorter than the one taken from the crank end of the cylinder. Separate indicators were used with pantograph reducing motion, and the cords from both indicators were attached to the same pin on the pantograph. The cord from the indicator on the head end passed back of the indicator over a pulley and was attached to a spring which was hitched to the floor; that is, the indicator cord was hooked in a loop of the cord connecting the pantograph to the spring. It may be possible that the cord stretched enough to make ¼ in. difference in the diagrams, but it was one that had been used many times and showed no signs of stretching when tried with the hands. The spring attached to the floor was a very weak one and it seems incredible that it should cause the cord to stretch. I should like to hear from POWER readers regarding these diagrams.

R. A. CULTRA.

Cambridge, Mass.

A Hot Box Cure

At the mill where I am employed as engineer, I have had trouble with the bearings next to a 44-inch drive pulley on the line shaft, which is belted direct to the engine. The whole load of the mill on these bearings caused them to run hot.

I tried different remedies, but nothing seemed to help them until I removed the oil cups and poured in some kerosene, letting it run through the bearings while they were in operation. I allowed the shaft to run thus for a few seconds and then poured in some castor machine oil, and after that some more kerosene oil, and finally, in a few seconds, I applied more castor oil.

After thus applying kerosene and castor oil several times, I poured water through the bearings and washed them out and then applied cylinder oil. After this I replaced the oil cups. The bearings soon began to run cool and have not given any further trouble.

This treatment seemed to take the dirt and grit out of the bearings and polished the shaft.

I also remedied the main bearing on the 14x18-inch engine, which has a 6-inch shaft. Kerosene cuts the film of oil between the shaft and babbitt and brings them into contact close enough to loosen the dirt and grit, and smooth off the rough places. The shaft seems to polish up better for this treatment.

Care should be taken not to allow the bearing to run more than a few seconds in kerosene without applying castor oil.

G. D. WIANT.

Seattle, Wash.

Need of Trades Schools

At the present time the number of trades schools in the United States is very small. If a comparison is made between the number of people employed at trades and the number of professional and cultured men and then between the number of professional and cultural schools and high schools, and the few trades schools, a good example is had of an inverse ratio.

Germany and a few other European countries have well established and successful trades or continuation schools.

Why, then, should the United States, having, as we believe, no equal in the other countries of the globe, be so tardy?

I am glad that there is room for belief that the people of the United States are waking up fast to this great need.

From the information I have been able to secure I believe that Massachusetts and New York were the first states to legislate for the promotion of industrial education and both of these states have several vocational schools in an embryo state.

Following the example of Massachusetts and New York, during the year 1911, 11 states legislated for industrial and trades training; besides, Mr. Page introduced a bill in the United States senate providing for national aid in cooperation with the states for industrial training.

At present, excepting the United States Indian schools and a few high schools in Massachusetts and New York, the schools teaching operating engineering are run by private individuals.

In every engineering course, mathematics and the machinist trades are requisites.

It is all well enough to say that if a boy wants to be an engineer, he should study; so he should, but until the states start such schools, if he learns the machinist trade he has gained only one big

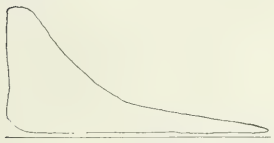


FIG. 1

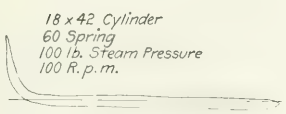


FIG. 2

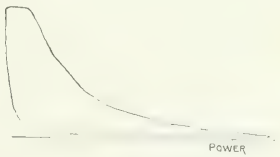


FIG. 3

THREE DIAGRAMS FROM THE SAME ENGINE

produced those I had taken. An examination showed many good diagrams among the first ones taken, but the last ones were the same as mine. This made a difference of 2 hp. in the friction load on the head end of the cylinder.

Even with this change a strange feature was noticed by comparing the head-end diagram with one taken from the crank end. Although the change in the length of the cord brought the diagram back nearer the center of the card, the head-end diagram is about ¼ in.

step upward, toward being a high-class engineer.

In the government Indian schools the practical side of engineering is being taught with enough of the theory to enable graduates to secure licenses.

At the Cushman Trades School in Tacoma, high-school pupils of the city schools will be allowed to learn the woodworking or machinist trade or operating engineering. The school was opened to the public on Jan. 1, 1912, and may be said to be the first trades school in the United States to have been equipped by the government.

If engineers want to further their interests they must organize and educate themselves, and, if necessary, get on the school boards and help start technical high and trades schools. If a demand is created for operating-engineering schools it will be supplied, but the quicker the engineers act the quicker they will come.

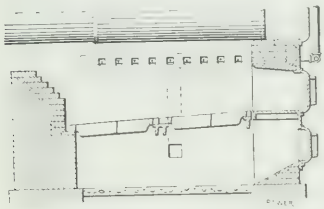
ROY V. HOWARD.

Tacoma, Wash.

Home Made Smoke Consumer

The engineers of a steam plant were arrested periodically for violating the smoke ordinance. This resulted in the frequent changing of engineers, and finally a smoke consumer of good repute was purchased and installed, but it failed to come up to expectations. A new engineer came and he put up a smoke consumer of his own make which brought about the desired results.

A 1-in. steam pipe was brought down



DETAILS OF SMOKELESS FURNACE

in front of the boiler and branched off into two ¾-in. pipes below the smoke-box doors, one for each side of the furnace. These pipes extended into a channel 4 in. square which was built inside the firebrick wall well above the grate line. Eight 2-in. square holes evenly spaced opened from this channel into the furnace.

The channel was also connected with the ashpit by means of a vertical channel 4 in. square. The ¾-in. pipe was tapped for eight ⅜-in. steam nozzles, the nozzles being made to correspond with the opening in the horizontal channel. As the steam was turned into the steam nozzles, it would induce draft, drawing air from the ashpit into the furnace. As the steam is regulated by hand, any amount of draft might be induced, as required.

VICTOR BONN.

New York City.

Wanted: Engineer Who Can Iron Shirtwaists

According to the papers, this is a day of specialists, but the rule does not seem to hold good in the case of engineers.

I have been in places where they expected one to be a first-class engineer and be well up on plumbing, blacksmithing, masonry and tinsmithing, but I met with something new not long ago.

While in a large Western city I noticed an ad calling for an engineer-laundryman. I called and found it to be an institution run by a state organization. I informed them that I could run the engine, boilers, steam-heating plant and the laundry machinery as well as look after the plumbing, having had experience in all those lines.

Then the superintendent stumped me by asking if I could iron shirtwaists. I confessed my ignorance and did not get the job. Next!

FRED ECKLEY.

Bakersfield, Cal.

Dirty Boilers Cause Trouble

A few years ago I ran, as night engineer, a lighting and heating plant. The outfit consisted of one 175-hp. water-tube boiler and two 80-hp. fire-tube boilers. One 50-kw. and one 100-kw. engine. The boilers were fed from a receiver which received the returns from the heating system, but there was no oil separator or filter in any of the return lines.

Everything went nicely so long as the load was light, but as soon as a heavy load came on, then the trouble began. The large engine would begin to cluck like a setting hen, and then I had to close the throttle and open up the bypasses to the traps connected to the steam separators. While this was going on the lights were burning dimly and then the consumers would protest.

The only cause for this trouble was that the boilers were not properly cleaned. They would run four weeks with no trouble without washing out; after that I had to look out. The chief was satisfied with conditions and that settled the matter.

Another heating and lighting plant contained four 400-hp. water-tube boilers. The chief engineer congratulated himself because his boilers were so free from scale, but the fireman complained that the boilers were steaming hard. A tube-cleaner was purchased and tried out, and the back end of every row of tubes was found to be badly scaled. Cleaning the tubes every three months kept the boilers in good condition.

The Corliss engines were of the cutoff type for overloads up to 75 per cent. When an overload came on the engine, the receiver pop valve would blow and the vacuum would be lost. Then the load had to be thrown off before the vacuum could be reëstablished. This would happen six or eight times daily. The cause for this was found to be due to the reach rod on the high-pressure side controlling the knockoff cams being too long and more steam went to the receivers than the low-pressure cylinder could take care of. As soon as this rod was shortened the troubles ceased.

The low-pressure cylinder had two set of packing rings in the piston; the high-pressure cylinder had one piston-packing ring. It was noticed that the packing ring did not reach the counterbore at each end of the stroke of the piston by ⅜ in. The low-pressure cylinder was nice and smooth to the counterbore, but in the high-pressure cylinder a shoulder was formed and as soon as the old packing rings were worn out the trouble commenced. New rings were put in but were soon broken.

Engineers should be sure when an engine is set up or when the cylinder has been rebored that the piston ring overlaps the counterbore a trifle. When a cylinder gets a shoulder ⅛ in. deep, there is only one sure remedy, and that is, rebore the cylinder and fit a new piston.

The water for boiler use in another power plant was taken direct from a small river and every time it rained the water became very muddy. After a boiler was cut in on the line the blowoff valve was never opened until the boiler was washed out, a period of from four to eight weeks. Sometimes there would be so much mud that a jack would have to be placed against the manhole plate before the mud and water could be got out of the boiler. When a heavy load came on the engines, and the fireman began to crowd the fires, mud and water were carried over into the engines, the vacuum was lost and the engines then exhausted to the atmosphere. Then down went the voltage. Things were no more than straightened out again when the same things would repeat themselves.

One day a heavy load came on a small tandem-compound engine and then suddenly went off; the governor opened up and stuck; the engine began to race, and before the throttle could be closed the engine had attained a dangerous speed. Shortly after this experience the same engine again ran away and was not brought under control until it had shattered the flywheel, one half striking the switchboard; the other half struck against the wall and fell into the pump pit.

E. E. MILLS.

Chardon, Ohio.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Designing a Bearing

I have read Prof. Heck's criticism, in the Jan. 23 number, of my article in an earlier issue. He must admit that there is a considerable difference between a bearing with a steady motor or belt stress and that of a reciprocating engine with its alternating stresses. In accordance with his theory, a single setscrew would hold a quarter box on an engine. This has been tried only to fail, because with the constant changing of the thrust from one side to the other, and the consequent flexure of the shaft, the setscrew forms a kind of hinge for the quarter box to rock upon.

Two setscrews are now generally used, whether the engine is of the side- or center-crank type. I have seen cases where a vibration which could be felt when standing upon the cement floor could be stopped by setting up on the setscrews of the quarter box, especially on those next to the crank.

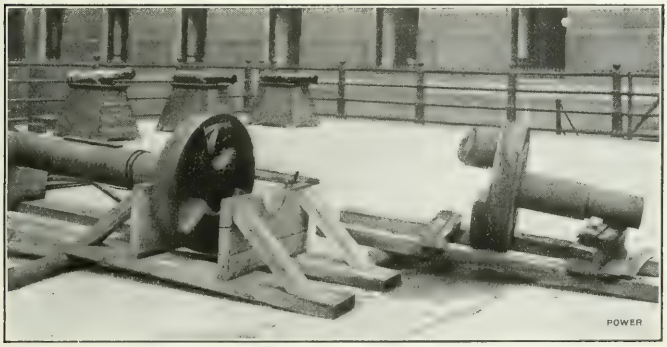
I have seen lots of other bearings in trouble from this same cause, and crankshafts with such bearings, although very heavy, fail right along. The accompanying figure is of a very large crankshaft which was run in the bearing referred to in my article, and I hope later to present photographs showing the wabbling of the wheel being recorded by a deflection gage, and also of the wrecked wheel. This matter cannot be treated the same as the stresses on a crane hook or a hydraulic lift, but is one of those examples where two forces are acting in unison, one due to the vibratory effect of the flywheel and the other to the pressure upon the piston.

When Prof. Heck says that there is no high-speed engine on the market the shaft of which is light and flexible enough to permit serious vibration of this sort, he betrays lack of experience with or observation of this kind of engine in actual operation. Those who have had to make these cranks over in considerable numbers have different views, and I know that solid-crank failures are fewer with engines having wedge or two-screw quarter boxes.

His statements about flexible bearings for line-shafting and steam turbines are all right, but they do not apply to the case.

C. R. McGAHEY.

Baltimore, Md.



BROKEN SHAFT WHICH RAN IN POORLY DESIGNED BEARING

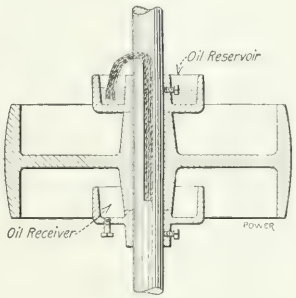
Muleshaft Lubrication

A. E. Derby, in the Jan. 9 issue, tells how he overcame a troublesome muleshaft by increasing the size of the pulley so as to reduce the speed to 180 r.p.m.

In the plant of which I have charge there are two mule drives; one carries a 16-in. heavy double belt 94 ft. long and the other a 14-in. heavy double belt 86 ft. long.

The accompanying figure shows the oiling arrangement I designed for these drives. The pulleys run at 450 r.p.m. and have never been repaired, although in constant service for nine years; they run as smoothly as when they were first put on and not one drop of oil has reached the belts from these pulleys.

The pulleys are of cast iron, not bushed; the hub is long, being only 1 in. shorter than the face of the pulley; the shafting is of turned steel. The oil reservoir and receiver are of cast iron and act as collars. The oil groove in the shaft is ⅜ in. wide and $\frac{7}{16}$ in. deep, holds about four strands of candle wicking and is cut in the shaft just opposite to where the pressure of the pulley comes.



ARRANGEMENT FOR OILING MULESHAFT

The oil reservoir holds about ½ gal. of oil and has to be refilled about every two weeks; we renew the wick once a year. To do this, we put a prop under the pulley and loosen the setscrew on the oil receiver and drop it; then pull the old wick out, soak the new one in oil and pull it through with a piece of wire.

JOHN HOPKINS.

Quincy, Ill.

Kerosene in Blowoff Pipe

In reference to Mr. Stambaugh's letter in the Jan. 9 issue under the above caption, I suggest that the oil in the blowoff pipe and valve was trapped by a depression somewhere along the elevation of the blowoff system; otherwise it certainly ought to have risen to the surface of the water in the boiler.

Whether the trap was caused by the conformation of the blowoff system or whether it was temporarily caused by scale sticking in the pipe is for Mr. Stambaugh to decide. I do not think that there would have been any danger of an explosion had the oil not leaked out.

JOHN S. LEESE.

Manchester, England

Plugged Boiler Head

The plugged boiler head described by W. G. Walters in the Dec. 26 issue brings to my mind a somewhat similar case in my experience.

The manager of a large hotel ordered from a reputed reliable foundry company, a large cast-iron steam-roasting kettle, and they were notified that a steam pressure of 80 lb. would be used in the kettle.

The kettle was made and delivered. The engineer in charge put a cold-water test pressure of 200 lb. upon the kettle and no leak showed. It was then connected and put into use and in a few days a leak showed on one side of the kettle. Upon examining and testing around the leak, a flaw was discovered in the casting from ¼ to ¾ in. wide and over 9 in. long. This space had been filled with a metal similar to babbitt, and after this had been well calked, the spot had been colored to resemble the iron.

The foundry was notified and the head of the casting room confessed that he was responsible for filling the cavity with soft metal. Of course, a new kettle was supplied.

In my estimation, a person who will do tricks of this kind should be severely punished, for several lives might easily have been lost if the kettle had gone to pieces while in use.

JOHN THORN.

Toronto, Ont.

Engineers' Wages

In almost every issue space has been given to the under-paying of engineers.

The fault lies with the engineer himself. Of most classes of men, the engineer is the least progressive. By progressive, I do not mean that he does not advance in knowledge, for he is usually industrious, but he lacks the push and courage to go to the "man higher up" and make suggestions or even ask for a well deserved raise. This is true of almost all shop employees; they are slow in coming forward, preferring to sulk and stay behind till they are driven to leave and look for something else.

Let any engineer who thinks he does not get a just return for what he gives his employer, ask himself if he has ever done anything toward getting higher wages. He has read much, seen where improvements could be made to good advantage in his engine room, but has he ever taken the matter up with his chief instead of telling the fireman that "if we installed a ———, we could save a whole lot"?

That is where all the trouble lies. If he gets good returns out of his machinery, why, this is what is expected of him; he is paid to do that, and it is seldom that a superintendent will, on his own initiative, say, "Well, Bill, I see you have been doing excellently; from Saturday on you will get an increase."

The engineer is on the spot, he sees where improvements can be made, and it is from him that suggestions and recommendations should come. In this way alone, it seems to me, will the present position of the operating engineer be elevated.

NATHAN OWITZ.

New York City.

Breakage of Separator Gage Glasses

J. W. Dickson's letter in the Jan. 9 issue refers to a condition which has interested me, and I have often heard other engineers refer to the same subject.

I believe this solution to be correct: Steam and water pass through the separator at high velocity. As the glass offers a path there will be a flow through

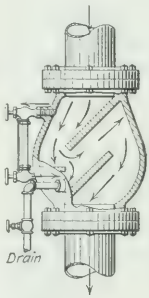


FIG. 1

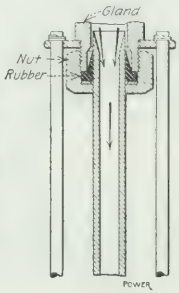


FIG. 2

it, as shown in Fig. 1, especially when the separator is well drained of water. This flow can be detected by observing the little slugs of water intermittently projected through the glass. The wear of the glass can be seen on an old used glass as they usually wear thin at the top end, as shown in Fig. 2.

WILLIAM C. THORNE.

Vineland, N. J.

Follow Up Methods

Under the heading, "Using the Firm's Stationery," we have had several examples of follow-up methods. My experience with one concern has "queered" it with me for the future. I wanted to buy a flue cleaner and as practically all the manufacturers advertised their machines on trial, I wrote to three of them, asking the following questions: "What is the price of your cleaner? Have you any circulars explaining its construction and operation? What kind of power do you use? Will you send it to be tried out against several others?"

Two of them sent the desired reply. The first I heard from the other was through our general manager. He found the cleaner in the receiving room and told me to return it without trial as he would not use that type of machine. There really was nothing against the cleaner but the manager's prejudice, but his word was law, and back it went. A letter explaining the situation went with it and was the beginning of a long correspondence.

The manufacturers wrote me of the saving to be made, of its amazing wearing qualities and of the small amount of power it required, and they answered all my criticisms. They also sent me the names of everybody who had ever used the cleaner, accompanied by enough testimonials to make the patent-medicine people look sick; one of them was from the makers of our own boilers.

My position was very uncomfortable, for I agreed with them in all their arguments but did not dare to admit it. Had I written them acknowledging the merits of their machine, they would undoubtedly have forwarded a copy to our manager. Knowledge of the fact that we had bought a competitor's machine failed to stop the flow of letters, but our indifference finally ended the matter.

The foregoing example of follow-up methods may be good business, but had these people answered my letter instead of forwarding the machine, they would probably have made a sale, as I liked their machine the best and could have convinced those higher up, had the manager not expressed a snap judgment.

JOHN BAILEY.

Milwaukee, Wis.

Corresponding with Manufacturers

Reading C. E. Henry's letter, "On Quoting Prices," in the Jan. 23 issue, reminded me of an incident that occurred some time ago when an air pump failed.

After locating the trouble, which was due to worn parts, I immediately wrote the manufacturers, asking them to send me by return mail a descriptive catalog showing the various parts. I gave them the size, type and number on the name plate of the pump, also the date of its purchase. My letter was written on the company's stationery, but I cautioned them to address me and gave my home address.

In about three weeks the manager handed me a letter addressed to the company, "Attention Mr. Dickson." Its contents were something like this: "We are mailing you under separate cover a catalog of our latest pattern air pump, also a price list of duplicate parts." They did not mention the old-style pump, and this later pattern was entirely different from the one we had. After a delay of about 40 days, I decided to have the parts duplicated at a local shop.

J. W. DICKSON.

Memphis, Tenn.

What Means the Dome?

I think that the following will answer the question raised in the letter under the above in a recent issue:

The South is what the Northern man would term "The Land of Wonders" when it comes to looking over a logging road. Some of the hills over which these little logging locomotives haul eight or ten carloads of logs are a caution.

The water tanks from which these dummies draw their supply are ponds close to the track, full of mud, moss and decayed wood which naturally cause the boilers to foam, and the engineer with 10 cars of logs behind him, a good stiff 6 or 7 per cent. grade ahead, dinner ready at the other end and 10 miles to go, could not stop if he would, so on many of the locomotives they have tried different methods to avoid priming. The dome on the locomotive in question is probably one of the means to this end.

B. F. Browne.

Yellow Pine, Ala.

The Handicap of Equipment

One phase of the isolated-plant question that is sometimes not taken into account when saying that the engineer is at fault if he does not show a saving over central-station prices is the ridiculously unmechanical "hook up" of the plant and the poor machinery with which he sometimes has to work.

The most extreme case under my observation was in a plant which should have been laid out for the combined service of light, heat and power. Every factor was favorable; the buildings were all close together on a side hill, the power house could have been put anywhere on the lower side and an unfailing supply of soft water could have been brought by gravity to the boiler room by laying not over 500 ft. of pipe.

There was nothing to hinder running the exhaust mains underground and nine-tenths of this work could have been done by inmates of the institution. Who the consulting engineer was, if there was one, I do not know, but in the first place there was probably somebody with about 15 heaters to sell who had a friend on the board of governors. These heaters, of course, are burning expensive hard coal. Added to these is a second-hand engine and a shunt-wound, 110-volt dynamo where a 220-110-volt three-wire system would have been more satisfactory. Two vertical boilers complete the outfit, using city water which is the hardest water I have ever seen.

It is reasonably certain that with good apparatus and a vacuum-heating system, the exhaust would do three-fourths of the heating in ordinary winter weather and the total soft coal burned for all light, heat and power would not cost more than the hard coal used for heating alone under the present system. In order to get started right now it would mean throwing away nearly everything and beginning at the bottom.

No engineer can combat conditions like these and compete with the figures offered by the central station.

V. L. Barber.

Punxsutawney, Penn.

The Standard of Consulting Engineers

I noticed the editorial in the Feb. 6 number on "The Standard of Consulting Engineers," and I take pleasure in pointing out that an organization has been in existence in this country, called the American Institute of Consulting Engineers, for several years, being formed prior to the English organization.

The American Institute commenced first in 1905 with a small body of professional engineers who were largely concerned with architectural engineering, and about two years ago it enlarged its scope so as to include all branches of the profession. Its membership (61) contains some of the leading engineers of America, representatives of the different branches, civil, electrical, mechanical, and has already adopted a code of ethics and schedule of fees.

Following this example, an organization of consulting engineers has been formed on the Pacific Coast called the Association of Consulting Engineers of the Pacific Coast, the secretary of which is C. Dorleth, Jr., of Berkeley, Calif.

E. W. Stern.

New York City.

Took Gases from the Uptake

The articles on burning uptake gases by Messrs. Breckenridge and Steely, in recent issues of Power, interested me. I had opportunity to test an arrangement similar to the one described by Mr. Breckenridge with the following exceptions, to wit:

First. An engine-driven fan was used in lieu of the steam jet.

Second. The recirculating pipe was provided with an opening controlled by a suitable damper, through which boiler-room air was drawn to "sweeten up" the uptake gases.

Third. A damper was provided in the recirculating pipe and ahead of the fresh-air opening to control the amount of recirculating gases independently of the fan.

The apparatus was a so called smoke consumer and fuel economizer and had been installed by the promoting company on a rigid guarantee of abolition of the smoke nuisance and a substantial fuel saving.

Evaporative tests were conducted with and without the apparatus in use, and while they were not entirely satisfactory from an evaporative standpoint, the draft readings and the gas analyses were conclusive proofs as to the merits of the apparatus.

Draft readings with the apparatus in use showed the draft in the uptake to be greater than the suction of the fan, and the analyses of the fan-discharge gases gave results identical to boiler-room air which alone showed that the apparatus was not being operated in accordance with the installers' claims, and this condition existed after the installing engineer had advised us that adjustments had been made whereby the claims of the company were being fulfilled.

After attention was called to the condition of the drafts, an attempt was made to circulate furnace gases only, but was soon given up as the steam pressure steadily dropped, in spite of the fact that the firing was almost continuous, and in addition to this the escaping gases blown out of the fire-doors and leaks in the setting were so oppressive that they were unbearable.

The claim of the company that its apparatus takes smoke from the smoke breeching, mixes it with air and returns it to the furnace and there consumes it was not substantiated by the tests. As a matter of fact, the results were very much poorer when the attempt was being made to exhaust gases from the breeching and return them to the furnace than when air was taken wholly from the boiler room independent of the breeching in the same manner as in all ordinary forced-draft equipments.

The conclusions drawn from these tests were that the apparatus was without merit.

J. B. Harris.

Minneapolis, Minn.

Underfeed Stoking vs. Overburning

I cannot make some of Mr. Woolson's statements agree with my conception of furnaces and the chemistry of combustion.

In one place he states, "It is impossible to get perfect combustion and maximum temperature under a boiler by feeding the coal up from below, and forcing air up through the incandescent mass of fuel, although it is possible to obtain high temperature in the mass of fuel itself." As we know that it is impossible to maintain perfect combustion, we must suppose that he means comparatively perfect. His statement then is that comparatively perfect combustion cannot be obtained with an underfeed stoker because, as he adds later, of the deep fire above the tuyeres, driven by a forced blast from below.

Mr. Woolson endeavors to show us how "the air on entering from the ashpit gives out its oxygen to the glowing carbon on the bars and generates much heat in the formation of carbon dioxide." And that these CO_2 molecules, on rising through the remainder of the fire, take up another atom of carbon, making each CO_2 molecule change to two molecules of CO, in which condition, due to lack of oxygen, they pass through the uptake with the resultant loss.

The visual testimony of the formation of CO_2 in any great quantity in a furnace is a more or less white fire, while that of the formation of CO is an orange or reddish fire. Has any reader ever looked through a properly appointed observation hole of an underfeed furnace where no air was admitted over the fire and noted a fire burning white in under and red on top? Never having seen it myself, I cannot help thinking that Mr. Woolson must, in some manner, have got his fire upside down.

The fact that the elements of combustion—coal and air—are fed from in under, through and between the tuyeres of an underfeed stoker at or near boiler-room temperature, makes "glowing carbon on the grate bars" or tuyeres an impossibility in an operating furnace. The temperature at the grates is low, but rises with the elevation of the fuel; reaching maximum at or above the fuel bed.

Underfeed stoking produces at least two zones of combustion. The first and nearest to the tuyeres might be termed the coking zone, where, due to the low temperature of vaporization of hydrogen, the different hydrocarbons are distilled or liberated from the coal in the pressure of the entire air supply of the furnace, ready to unite chemically with the oxygen in the air when the proper temperature is reached. The other zone is that part above the coking zone having a temperature exceeding that of the vaporization of carbon.

Due to the formation of the fuel bed, the air passes through it in streams or irregular columns which, though small when compared with visible objects, are, when compared with the size of molecules, of immense proportions. As the vibratory action of the carbon molecules is of insufficient magnitude to project them into this air column, the atoms of carbon can only come in contact and be saturated with such oxygen atoms as are exposed and clear of four times their volume of nitrogen on the outer atomic film of the air. After this no more oxygen is available until friction and molecular disturbance have displaced the intervening nitrogen, without considering argon and several other substances present in the air in small quantities.

All this goes to show the process of combustion is so slow under practical conditions as to make it impossible for the air to give up all its oxygen on or near the grate bars, and that the passing of oxygen through the fuel bed into the combustion chamber for the benefit of the unburnt gases is merely a problem of draft pressure, to be determined by gas analysis and experimental speed ratios of blower and stoker. This determination is made on the installation of most stokers, the blowers being so speeded as to force through the fire the minimum amount of excess air consistent with maximum combustion. Flue-gas analyses made during stoker tests, many of which have been published, will show this to be a fact.

The natural-draft, hand-fired, stationary-grate furnace, without smoke consumers or means of admitting air over the fire other than through the fire-doors, will, if intelligently stoked, and without air holes due to lack of fuel, produce rather high percentages of CO_2. Still, such a furnace provides the conditions—"where air has to pass through a body of incandescent carbonaceous matter"—which Mr. Woolson informs us would produce only CO.

WILFRED E. BERTRAND.

Philadelphia, Penn.

Smoke Prevention with Steam Jets

I was interested in the article under the above title in the Jan. 16 issue, and especially in the Ringelmann chart readings shown in Fig. 4 thereof, which show the performance of the plant with reference to smoke before the steam jets were applied and after they were put in use.

The article says: "A comparison of the two charts utterly fails to indicate the degree of smoke abatement accomplished." I would like to state that the lower chart also utterly fails to show the large amount of smoke that was actually made during this test. The chart was made by taking one-minute readings and I believe that this method is not accurate enough to give an idea of the performance of the stack.

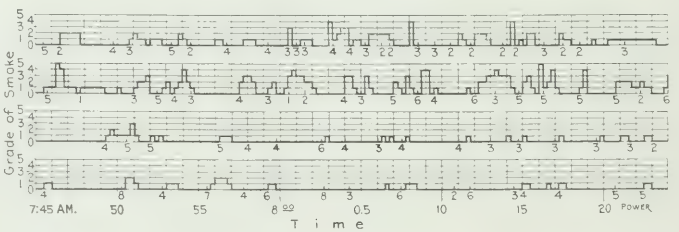
In Chicago we take 15-sec. readings according to the Ringelmann chart. The accompanying figure shows a section of a Ringelmann chart plotted from 15-sec. observations. The density of smoke as given is the average density for the 15 sec. previous to the time stated and not the density at the instant of recording the smoke. A record made in this way, therefore, gives a more accurate indication of the actual smoke made and the length of its duration. The figures on the base line of each record indicate the number of scoopfuls of coal fired. I do not believe it is generally appreciated how closely smoke is read in Chicago.

It has been found by experience that steam jets in themselves could not be considered a complete solution for the smoke problem, although in many cases they offer a great advantage, and when used with proper furnace construction and brickwork in the combustion chamber, make a combination which can easily run inside of the Chicago ordinance.

O. MONNETT,

Smoke Inspector.

Chicago, Ill.



SECTION OF SMOKE CHART BASED ON 15-SECOND READINGS

The "Clean-up" Spirit

I like the spirit of that story appearing on the foreword page of the Jan. 30 issue of POWER.

It must not be inferred that the firemen mentioned as "a clean-looking set of men" were at that moment clad in spotless garments, with faces free from grime, but it was apparent that there was a "clean up" with them at quitting time, while with the chief there was not.

I expect there was a decent place for the men to dress in and hang their street clothing in this plant. In many places one takes chances and places his clothing where he believes there is the least coal dust, etc.

Suitable accommodations can easily and cheaply be made in most plants for hanging up clothing and for the men performing their ablutions. These should be provided in every case to encourage the "clean-up" spirit.

LLOYD V. BEETS.

Nashville, Tenn.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Outside Diameter of a Gear

What is the rule to find the outside diameter of a gear?

M. O. R.

To find the outside diameter of a gear with standard teeth, divide the sum of the number of teeth plus two by the diametrical pitch. Expressed as a formula, it would be

$$\frac{\text{Number of teeth} + 2}{\text{Diametrical pitch}} = \text{outside diameter}$$

If the teeth are not standard, the rule is the sum of the pitch diameter and the product of the addendum multiplied by 2. A standard tooth is one in which the line of pressure is 14.5 deg.

Heat Required to Convert Ice to Steam

What amount of heat would be required to transpose 10 lb. of ice at 18 deg. F. to steam at 30 lb. pressure absolute?

L. R. G.

The total heat of 1 lb. of steam at 30 lb. pressure absolute above 32 deg. F. is 1163.9 B.t.u. The heat required to convert 1 lb. of ice at 18 deg. F. to water at 32 deg. F. is the sum of the latent heat of ice and the product of the rise in temperature of the ice multiplied by its specific heat. Substituting figures, the rule would be expressed thus: $142 + (14 \times 0.504) = 149.056$ *B.t.u.* The heat required to raise 10 lb. of ice to steam at the above pressure is

$$(1163.9 + 149.056) \times 10 = 13{,}129.56 \text{ B.t.u.}$$

Load Raised by Drum

If the average pressure on the piston is 60 lb., what load will a 24x36-in. engine connected direct to an 8-ft. drum raise in one revolution?

L. W. R.

An engine of 24 in. cylinder diameter contains 452.4 sq.in. and the pressure on the piston is

$$452.4 \times 60 = 27{,}144 \text{ lb.}$$

In one revolution the engine will develop

$$27{,}144 \times 3 \times 2 = 162{,}864 \text{ ft.-lb.}$$

per revolution. One revolution of the drum will raise the weight

$$8 \times 3.1416 = 25.133 \text{ ft.}$$

and the pounds raised by the drum in one revolution are

$$\frac{162{,}864}{25.133} = 6480 \text{ lb.}$$

Ampere Load to Raise Coal

What would be the ampere load on a 250-volt motor to raise 2500 lb. of coal 150 ft. in one minute if the efficiency of the apparatus is 50 per cent.?

R. L. W.

To raise 2500 lb. of coal 150 ft. per minute would require

$$2500 \times 150 = 375{,}000 \text{ ft.-lb.}$$

The horsepower required would be

$$\frac{375{,}000}{33{,}000} = 11.36 \text{ hp.}$$

The watts expended in raising the coal would be

$$11.36 \times 746 = 8474.56$$

The amperes required to raise the coal would be

$$\frac{8474.56}{250} = 33.9$$

If the overall efficiency is 50 per cent., the total amperes required are

$$\frac{33.9}{0.50} = 67.8$$

Soldering Aluminum

If aluminum can be soldered, what is the best material to use?

F. E. J.

Aluminum can be readily welded electrically, but soldering is not satisfactory. The high heat conductivity of the aluminum withdraws the heat of the molten solder so rapidly that it "freezes" before it can flow sufficiently. A German solder said to give good results is made of 80 per cent. tin and 20 per cent. zinc, using a flux composed of 80 parts stearic acid, 10 parts chloride of zinc and 10 parts chloride of tin. Pure tin fusing at 480 deg. F. has been employed as a solder, and soft solder with chloride of silver as a flux has also been used.

Receivers

Why is no receiver required for a tandem-compound engine?

J. D. R.

Both high- and low-pressure pistons of a tandem-compound engine transmit power to a single crank. The exhaust from the high-pressure cylinder can enter immediately into the low-pressure cylinder for the next stroke. With a cross-compound engine with cranks on the quarter, there is an interval of time between the exhaust of the high-pressure cylinder and the admission of the low-pressure cylinder; and the receiver is provided to store the discharge of the high-pressure cylinder during that period.

Power for Machine Tools

What power is required to drive a 36-in. lathe and a 15-ft. planer?

P. H.

A 36-in. lathe will require about 15 hp. Planers are rated by their capacity under the rail, and one 15 ft. long will require from 2½ to 7½ hp.

Effective Head

What is considered the effective head in a hydraulic turbine?

D. B.

Neglecting friction, the effective head with an impulse turbine is the distance from the level of the upper pool to the point of entry. The effective head cannot be increased to the level of the tailrace by employing draft tubes. In the reactance turbine the effective head is measured from the level of the upper pool to the point of exit. If draft tubes are employed, however, this head can be increased, within the limits of the atmospheric column, to the level of the tailrace.

Adjusting a Spring-Loaded Safety Valve

What will cause a spring-loaded safety valve to rumble on its seat, and how can it be remedied?

P. J. L.

If the safety valve does not pop cleanly or shows a tendency to rumble, the ring surrounding the valve which forms a huddling chamber is too low and should be screwed up.

Running a Condensing Engine Noncondensing

If the condenser of a compound-condensing engine running full capacity should become disabled, what should be done to keep the engine running on full load?

A. L.

Open the relief valve, let the engine exhaust to the atmosphere, and let high-pressure steam into the low-pressure cylinder through the bypass valve.

New York Chapter of Heating and Ventilating Engineers

The regular monthly meeting of the New York Chapter of the American Society of Heating and Ventilating Engineers was held in the Engineering Societies Building, 29 West Thirty-ninth St., New York, Tuesday evening, Feb. 13, at 8 o'clock, with President W. M. Mackay in the chair. The evening was devoted to routine business and a discussion on the subject of factory ventilation.

Announcement was made that at the March meeting two topics of interest will be presented: "Ventilation of Public Schools with Especial Reference to New York Practice," Mr. McCann, of the Board of Education, presenting some facts in regard to the New York schools, and "The Time Element in Regard to the Starting Up of House Heating Boilers."

At the April meeting the subject of "Air Washers and Humidity" will be discussed, and at the May meeting, "Artificial Cooling of Buildings, Steam Traps and Vacuum Systems."

$500,000 Plant Burned

On Feb. 6, fire destroyed the plant of the Barnard & Leas Manufacturing Co., at Moline, Ill., causing a loss of $500,000 and throwing 400 men out of employment. An explosion of accumulated gas in the furnace of one of the boilers set fire to a pile of shavings and the fire quickly spread over the entire building.

Water Tube Boiler Explodes

On Feb. 19 a water-tube boiler exploded at Wiggins, Miss., killing three employees and injuring the head fireman. Further particulars will be given in an early issue.

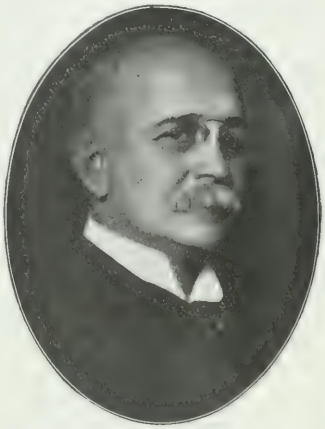
OBITUARY

John Burkitt Webb, who retired from the professorship of mathematics and mechanics at the Stevens Institute of Technology five years ago to practice his profession of consulting engineer, died at his home, in Hoboken, N. J., Feb. 18, at the age of 71. The funeral was held at the Church of St. John the Evangelist on Feb. 20, the burial taking place in Philadelphia.

Mr. Webb was a member of numerous scientific societies, and was known as the inventor of many devices for the measurement of power, among them being the dynamophone.

Mr. Webb was born in Philadelphia, Penn., in 1841 and received his engineering degree from the University of Michigan in 1871. He supplemented his course by extensive study at the universities at Berlin, Heidelberg and Paris, afterward becoming professor of civil engineering at the University of Illinois and later assuming the chair of applied mathematics at Cornell University. He went to Stevens in 1885. Mr. Webb married Miss Mary Emeline Gregory in 1870.

On Feb. 18, Francis H. Stillman, president of the Watson-Stillman Co. and prominent in the machine-tool and hydraulic-engineering field, died at his



FRANCIS H. STILLMAN

home, 105 Rodney St., Brooklyn, N. Y., in his sixty-second year. Mr. Stillman was born in New York on Feb. 20, 1850, and attended Yale College, from which he was graduated in the class of 1874, having received the degree of bachelor of science.

Mr. Stillman first embarked in business with the Cottrell Printing Press Co., severing this connection to engage in business with his step-father, Mr. Lyons. The firm of Lyons & Co. was succeeded in 1883 by Watson & Stillman, which firm was organized by Mr. Stillman. In 1904 it was incorporated as the Watson-Stillman Co., with Mr. Stillman as its president, which position he continuously occupied until his death.

His business ability soon placed the company in a very prominent position in the hydraulic-engineering field, and upward of 4000 types and sizes of hydraulic machines have been built by it.

Mr. Stillman was a member of Hyatt Lodge, F. and A. M., a member of the Thirty-second Degree in Aurora Grata Consistory, a Knight Templar, a Noble of Kismet Temple, Mystic Shrine, and of the Royal Arcanum, the Hanover Club of Brooklyn, the Engineers Club, the American Society of Mechanical Engineers, and treasurer and continuously throughout its existence, a director of the National Association of Manufacturers. He organized and was first president of the Machinery Club of New York, and was also first president of the National Metal Trades Association. He was also president of the Bridgeport Motor Co. and of the Pequannock Commercial Co., and a director in other manufacturing firms.

The many friends who loved Mr. Stillman for his high standard of business integrity, his genial disposition and for his kind personal interest in all those about him will feel most keenly his sudden death, particularly those at his office, as he came to business the day before his demise, and apparently was in good health.

Funeral services were held at his late home at eight o'clock Tuesday evening, Feb. 20, which would have been his sixty-second birthday, and the body was interred at Evergreen Cemetery, Brooklyn, on Feb. 21. Mrs. Stillman (who was Miss Irene A. Bancroft, of Boston, Mass.) and two sons, Austin F. and Edwin A. Stillman, survive him.

SOCIETY NOTES

The National Association of Stationary Engineers of New Jersey will hold its twenty-first annual convention in Newark, N. J., May 30 to June 2. It is the intention to make the exhibition a combination of a power-plant exhibit and a businessmen's exhibit, and arrangements have been made to accommodate about 100 exhibitors. Any further information may be had by addressing E. W. Sears, secretary of the convention committee, 109 Eleventh Ave., Newark, N. J.

PERSONAL

Edward C. Wright, Jr., has been appointed smoke inspector of Kansas City, Mo.

Albert R. Talcott, until recently chief engineer with Tiffany & Co., jewelers, at Forest Hill, Newark, N. J., will represent the Standard Oil Co. in northern New Jersey.

Hubert E. Collins, secretary of the Institute of Operating Engineers, has entered upon an extended trip to Brazil in a consulting capacity for J. G. White & Co., New York City.

Cadwallader Evans, Jr., superintendent of power for the H. W. Oliver power plant at Pittsburg, Penn., has resigned to become superintendent of mines and plant of the Arcadia Coal Co., Pictou, N. S.

John Williams, Commissioner of Labor of New York, has been invited to participate in a discussion on factory ventilation by the New York Chapter of the American Society of Heating and Ventilating Engineers at its April meeting in the Engineering Societies Building.

POWER

Vol. 35 NEW YORK, MARCH 5, 1912 No. 10

THERE are leaks and there are leaks.

A certain engineer once disbelieved this theory. He thought that there were only leaks—the visible or obvious kind. But he is won over now and he is quite convinced that it is possible, yea, even probable that in many plants there are leaks existing which cannot be detected by sight, sound, feel or smell. Serious leaks—leaks that go on day and night, cutting down efficiency and stealthily stealing money out of the office safe, for if it were not for these leaks a lesser amount of money would pay the coal bill and the difference would still repose in the treasury.

Our friend proudly called himself an "old-time engineer, and a thorough one, too, I'll have you understand, sir." He kept his plant in the best appearing condition imaginable. The brightwork on the engines and other machinery was truly bright. Dust, dirt and oil were never allowed to accumulate. One never discovered a steam leak at manhead, joint or valve; as soon as a leak developed it was stopped by putting in new packing or gasket as the case might be, for leaking steam costs money and he was a thorough engineer, you know. In a word, his plant was a model of neatness and order. But, as we have said, he did not think such a thing as an invisible leak could exist.

Steam-engine indicator salesmen had talked to him until they were "blue in the face," but much good it did them! He had successfully run his plant for years without an indicator and he guessed he didn't need one now at his time of life, etc.

Now, our friend had a son who had gone to a so called trades school; it wasn't as advanced as a college, yet it "dug into enough theory to get at the reason why of most things that transpire in an average power plant."

This son was wise beyond his years. He knew his pop was a "leetle" touchy on the score of "book learnin'," as he called it, yet not quite so much as to deprive his son of all the benefits of an education. So the son went slow and carefully felt his way.

One day, as a favor, the father let the son indicate the main engine. The diagrams indicated that a simple change in the valve setting would be beneficial and the son pointed this out to the old man in a diplomatic way. The old man was skeptical, but "game," and the change was made. The result was an appreciable improvement.

Later, the son got a flue-gas apparatus and to "humor" him the father let him make some tests; secretly the old man was gaining great confidence in the young one, but he hated to give in. After the tests the young man suggested that the draft and fires be managed in a different way. When this was done a very marked saving was effected.

Finally, after several similar experiences, the father capitulated and frankly admitted that there was more to successfully operating a steam plant than he had ever suspected.

He realizes now that a plant may look to be in first-class condition and yet be inefficient and waste money in every direction. Do you? If so, what are you doing about it?

Modern German Electrical Plant*

Description of a 10,000-kw. plant on the Finow Canal near Berlin, and the conditions which led to the several distinctive features in design.

*Reprinted from an article by Prof. G. Klingenberg, in die Zeitschrift des Vereines Deutscher Ingenieure.

The Finow Canal joins the Elbe and the Oder Rivers and includes in part of its length the Finow, a little river from which energy is still utilized through hydraulic plants. Along its banks, favored by the nearness of Berlin, lively industries have developed. The small horsepower of the Finow, however, has long since ceased to meet the demand, and steam power has from time to time been added until the Finow is now industrially far more valuable as a carrier of coal barges and of other freight than as a power source.

To supply this industrial district with electricity, the A. G. Märkisches Elektricitätswerk erected on the Finow Canal during 1909 an electrical plant which is herein described.

The preliminaries showed that as prospective consumers there would be principally brick and tile works with about 2000 service hours per year at a load factor of about 100 per cent.; factories with 3000 to 7000 hours and a load factor of from 40 to 70 per cent.; and communities and ranch farms ranging from 150 to 1000 hours with a load factor of about 35 per cent. As a first proposition, 3200 kw. were calculated as the maximum load at any one time; the second proposition was for 5500 and the third for 8800, and the load factor in view of the large power demand was estimated at from 35 to 40 per cent. From this was determined an individual machine size of 3600 kw. capacity with a power factor of 80 per cent., and in accord therewith the building was arranged to accommodate three steam turbines and six boilers having a unit hourly evaporative capacity of 26,400 to 33,000 lb. Of this equipment two turbines and three boilers were at first erected.

General Layout

A building site property was accordingly acquired on the banks of the canal, which was thus available for fuel delivery and for boiler feed and circulating water. A private dock was built to accommodate coal barges of about 200 tons capacity each; and alongside of the dock was located the coal-storage yard. The boiler and turbine rooms are adjacent to this in such a layout that the turbine room fronts on the canal, an arrangement permitting minimum lengths of suction and discharge tunnels. The electrical galleries are in a separate building connected to the turbine room by a covered way.

The coal yard is laid out for the storage of a four months' supply because during cold weather a regular delivery cannot be depended upon. The coal is taken from the boats and piled directly in the yard by means of a motor-operated traveling bridge crane capable of handling 40 tons of coal per hour; this is shown in Fig. 1. For future extension the inner or land-side runway of this bridge is so constructed that a second bridge can be erected to serve the space in front of a second boiler house.

Beneath the coal-storage yard are two reinforced-concrete passageways about 6 ft. square, through which an endless bucket conveyor travels. In the roof of each passageway there is a row of feed funnels through which the coal, stored above, falls to the conveyor. (See Fig. 2.) At the outer end of the storage yard the chain of buckets is conducted transversely above ground from one passageway to the other. Within the boiler house the conveyor is carried on the roof trusses and discharges by means of automatic dumpers which are installed in pairs in each bunker and may be operated from the firing level by means of a handle. The capacity of each bunker does not exceed a two-hour fuel demand per boiler as, in view of the operative reliability of the coal-carrying plant, a storage of coal in the boiler house proper seemed unnecessary. The chief advantage of this arrangement lies in the unusually small weight of the structural work and the absence of special columns.

As a bunker fills it is automatically cut out. Should all the bunkers be full, the buckets return unemptied to dump into a coal pocket on the boiler-house front through the action of a fixed tripper which tips all buckets a second time, and where the falling coal releases a trap which cuts out the operating motor. By alternating the filling of the buckets among different points at the storage yard different kinds of coal can be mixed. The length of the conveyor is about 975 ft.; it is operated by an 8-hp. three-phase motor and has a capacity of 44 tons an hour.

Boilers

The boiler house, Figs. 2 and 3, is designed for six boiler units, each consist-

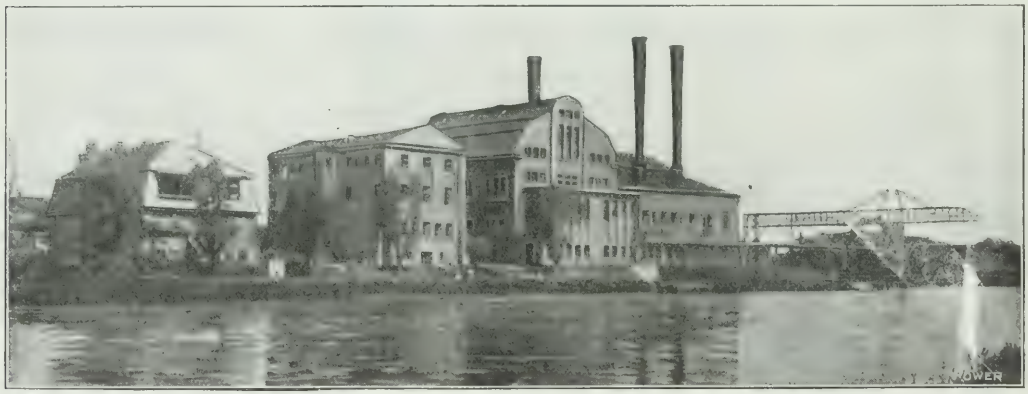


Fig. 1. Plant from River Side

ing of a boiler, an economizer, forced-draft appliances and a stack. The weight of the structural-steel work for the complete boiler house amounts to 213,400 lb., or one pound of steel per pound of water evaporated at maximum load. These unusually low figures were attained in part through the described arrangement of coaling apparatus and in part through a boiler construction suggested by the author and carried out by the Babcock & Wilcox Co., which combined surfaces of a boiler and its economizer are naturally less than with the usual separated arrangement. It is possible also, notwithstanding the relatively low stack height, to operate the boilers with natural draft up to about two-thirds of their maximum capacity, so that the artificial draft need be thrown in only for the heavy loads.

The forced draft is furnished by a Sirocco motor-driven blower having a capacity of 1.5 times the air requirement with normal and maximum power needs at 20 and 30 hp. respectively, and maintains a draft behind the economizer of about 1 in. normally or a maximum of about 1.5 in. The height of each stack from the boiler-room floor is 98.5 ft.

Fig 4 shows a cross-section through a boiler and its superimposed economizer. As can be seen, it is a self-contained group inclosed by a sheet-metal casing preventing the entrance of air. To guard against water being carried over into the superheater, a large receiver drum is placed over the boiler.

The boiler and the economizer of each unit are so designed that the hot gases enter the latter at about 750 deg. F., and the feed water is heated to about 250 to 285 deg. The ashes fall through hoppers under the ashpits to the basement from whence they are carted away.

The boilers are automatically fed by turbine-driven multi-stage centrifugal pumps, the speed being governed by a pressure regulator. The exhaust from these turbines is led to coil-type re-

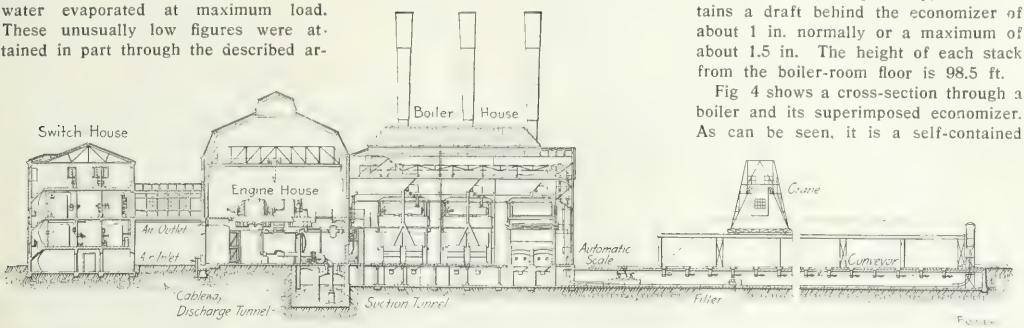


FIG. 2. SECTIONAL ELEVATION THROUGH PLANT, SHOWING COAL-HANDLING APPARATUS

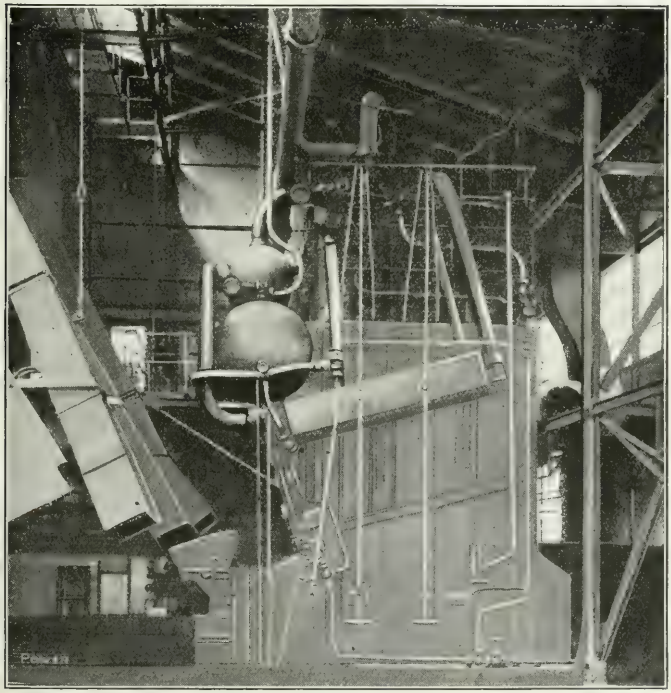


FIG. 3. SIDE ELEVATION OF BOILER

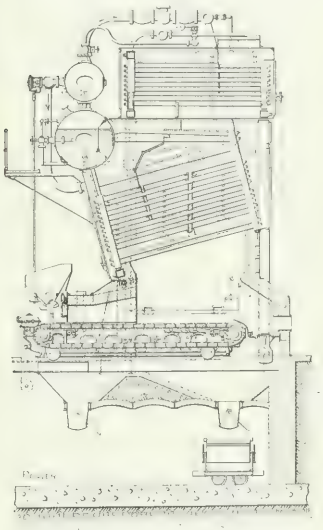


FIG. 4. SECTION THROUGH BOILER AND ECONOMIZER

from a thermal standpoint has been well justified.

Aside from the small ground-surface requirement, a further advantage of this construction appears in the small heat loss through radiation and piping, as the

Simplicity of service, the absence of dampers and the fact that the blower is called upon to deliver cold air only and can be set up to be conveniently accessible, are advantages due to the superiority in such cases of forced draft.

ceivers serving as primary feed-water heaters from which the water flows under pressure to the centrifugal pumps for delivery to the boilers.

Under normal conditions, each boiler unit evaporates 27,700 lb. of water per hour but has a maximum capacity of 34,600 lb. The heating surface per boiler amounts to 4400 sq.ft., each superheater 1450 sq.ft., and each economizer 2260 sq.ft.

Steam Piping

In Fig. 5 is shown the main steam piping. This consists essentially of a valves having "shut" and "open" indicators. The piping was laid out for a maximum steam velocity of 15,700 ft. per minute.

The nonconducting covering of the steam piping consists of siliceous earth, 2.375 in. thick, the flanges in addition being fitted with cast-iron covers with drip connections.

Water Supply

Water for condensing purposes is taken from a suction tunnel running parallel to the turbine room, and a similarly located discharge tunnel carries equipped with ejectors operated by saturated steam directly from the boiler.

Turbo-generators

The turbine room, Fig. 6, in its present stage of completion affords space for three turbo-generators each of 3600 kw. with a power factor of 80 per cent. These are designed for steam of a pressure of 185 to 215 lb. gage at a temperature of 570 to 660 deg. F. at the throttle and are provided with nozzle regulation which with small loads permits of a material reduction in the steam consumption.

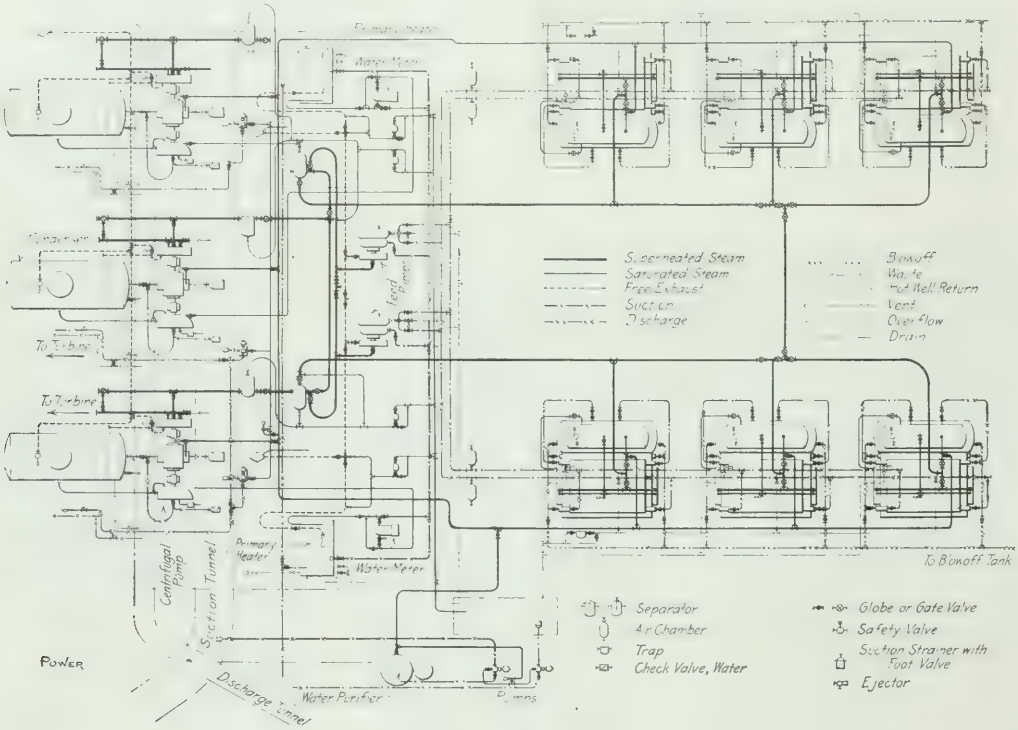


Fig. 5. Piping Layout

main line from each row of boilers leading to a main separator; these separators have a cross-connection from which lead the branches to the main turbines, each branch being provided with its individual separator.

The two main lines are cross-connected in the boiler room, but a true ring header is not thus established as the cross-section is not sufficient for the passage of the total boiler output. Seamless steel piping is used with cast-steel rolled flanges and spherical segment rings; the valves are of cast steel with nickel seats, and all valves may be operated from the boiler-house floor, the main

it back into the canal. The water circulation for the cooling of the turbine bearings is supplied by small motor-driven centrifugal pumps placed in the basement and in connection with the two tunnels mentioned.

For the boiler feed only small quantities of water need to be added; the water losses are small as the condensate from the feed pumps is free from oil and is fully recovered. As the water from the canal is hard, a purifier is used; from this the water flows to a reservoir into which also are returned the drips from the various separators.

All these centrifugal pumps are

The condensers, which are of the ordinary contraflo surface type, are each equipped with a rotary circulating and hotwell pump driven by a small steam turbine (see Fig. 7). The exhaust from these turbines is individually led to an intermediate stage of one of the main turbines. The condensate is passed through a water meter provided for each turbine so that it is possible at any time to determine the steam consumption of the turbine.

The generators operate with a pressure of 10,000 volts, maintained constant with Tirrill regulators. Each generator has a switch panel carrying the necessary

meters and in addition signaling apparatus for communication with the switchboard.

Switch Galleries

In providing a separate building for the switch galleries, the cost was but slightly increased (one more wall) and two more light sources were gained. This separate construction also has the advantage of being independent of inner constructive requirements of the engine house and electrical galleries in the matters of heights, column arrangements and roof constructions—advantages of value in later extensions. The often advanced argument that the electrical galleries should be in the closest possible communication with the engine house will not bear investigation; for the distributing installation, except for the voltage control of the generators, belongs rather to the transmission system than to the generators.

The claim that the switchboard attendant should see the machines is equally groundless; on the contrary, it is better that he be removed from the noises of the engine room and left to be entirely guided by the readings of his instruments. There are known cases where sudden machine failures have prompted wrong switch handling. The only necessary intercommunication of the switch galleries and the engine house concerns the cutting in or out of the generating units and their loading, and this simple intelligence is best conveyed by means of signals.

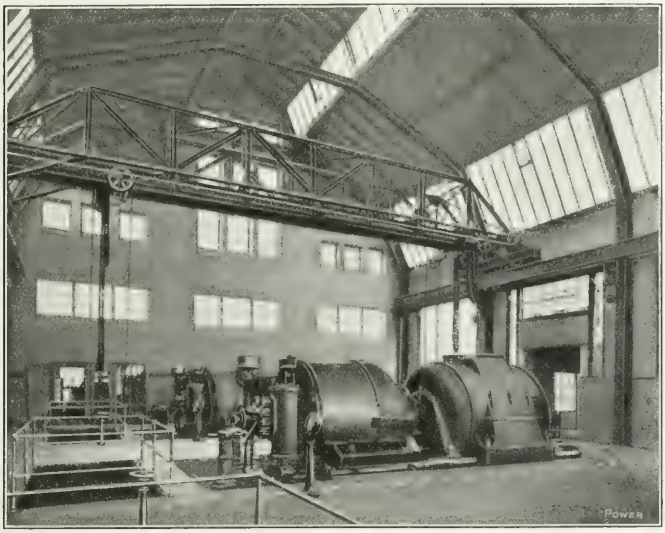


Fig. 6. Turbine Room

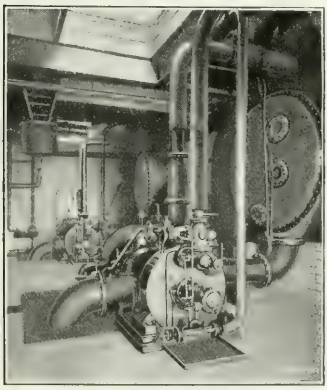


Fig. 7. Condenser Accessories

Corrosion of Condenser Tubes

A recent issue of *Engineering* contains a paper by Arnold Philip upon the corrosion of condenser tubes, the paper having been read before the Institute of Metals on Jan. 17.

Mr. Philip was of the opinion that only about 10 per cent. of the cases were serious, these being localized corrosion or pitting. Accordingly his remarks dealt almost exclusively with such cases as found in tubes of Admiralty composition —namely: copper, 70 per cent.; zinc, 29 per cent., and tin, 1 per cent. Of these cases fully 90 per cent. resulted from known causes which could have been neutralized or overcome by such preventives as bars of zinc, aluminum or iron. The presence of these so called electro-positive metals, however, is not alone sufficient to prevent corrosion of the condenser tubes immersed in the same bath of sea water. It is essential that there shall be a direct circuit between the tubes and the protecting metals and that both shall be immersed in the same electrolyte.

In this connection may be mentioned the practice in the British navy. Zinc and iron were originally used in condensers in which the body was of cast or wrought iron, and the sea water passed outside the tubes, and was therefore at the same time in direct contact with the outside of the metal condenser tubes and the inside of the iron case. Under these circumstances the protection was very complete, and while corrosion of the steel or iron casing took place, the corrosion of the tubes was practically unknown. Steel or zinc protector-slabs and bars have been used attached inside the condenser doors, or on the tube plates themselves, or some of the tubes of the condenser have been replaced by iron or steel, or even zinc, rods; while in some condensers, built about four years ago, the bodies were of metal of a composition closely approximating to that of the tubes, with the doors of iron or steel. More recently condensers have been made with steel bodies.

A peculiarity noted in nearly all the cases investigated by Mr. Philip was that the corrosion occurred along the bottom of the inside of the tubes. This would indicate that the trouble was caused by the contact of particles of carbon or ferric oxide, or other electro-negative solids deposited from the cooling water, and setting up a galvanic action. This action is increased when the condenser is not in use and the tubes remain full of sea water.

If, on the other hand, the condenser is emptied of water when not in use there would be a possible source of danger of corrosion along the bottom inside surface of the tubes, because this portion would be exposed longest to the joint action of salt water and air. It was suggested by Mr. Philip that this cause might be removed by employing vertical or inclined tubes.

The discussion following the presentation of the paper corroborated in general Mr. Philip's opinion, although the question was raised as to whether the presence of gases in the water did not have a decided influence in any corrosive action. It was generally conceded that they would, but no definite information was offered in support of this contention.

A special committee has been appointed by the institute to look into the subject of corrosion and its report will be awaited with interest.

It is this very feeling of "wanting to know" which distinguishes the man who means to succeed from the man who merely hopes that he will do so.

Steam Consumed by Vacuum Cleaner

By J. V. Hunter

Results of a test upon a steam-ejector type of vacuum cleaner, showing the steam consumption at different vacuums and loads with from one to four sweepers attached.

Within the past few years little has been recorded publicly of tests upon any of the systems which have been appearing on the market for the so-called vacuum-cleaning process. For this reason, tests which were conducted a few years ago upon a steam-ejector type of cleaner may be of interest on account of the principles involved and the results obtained as compared with those of other types on the market.

The system of vacuum cleaning has become so well known that little need be said in regard to its principles except that, like all machines, this blower was intended to exhaust air, the inrush of air thus created through suitable cleaning devices, nozzles, etc., being employed to draw dust and dirt out of carpets, upholstery and other household furnishings, the steam ejector which was tested being intended for heavy-duty service in connection with large office buildings, hotels, etc., where the boiler plant could furnish enough live steam for its operation.

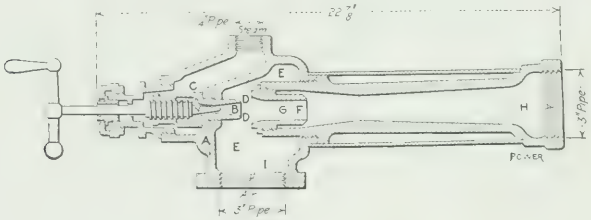


FIG. 1. SECTION THROUGH EJECTOR

HISTORY

The principle involved does not seem to be a new one; Kent's "Mechanical Engineers' Pocketbook" records sizes and tests on steam-air exhausters. Many of these were used in connection with mine ventilation in England between the years 1810 and 1850. The steam exhauster seems to have been inefficient for this service and, though quite popular for a short time after its advent, it did not continue long in service as the furnace ventilation process was less than half as expensive to operate.

It also appears that the reverse principle of this apparatus was used for some years in connection with the production of the necessary air-blast for blast furnaces. In this position it acted as a blower and was capable of producing air pressures up to one-sixth the pressure of the steam supplied for its operation.

In view of the modern developments of the Gayley dry-air blast system—wherein it has been shown that the efficiency of a blast furnace and its output may be considerably increased by refrigerating the air supplied in the blast to remove every particle of moisture, it is not surprising that the steam blower did not continue long in service for this purpose, since the air, being very heavily charged with steam, must have considerably decreased the efficiency of the blast furnace.

A section of the blower under discussion is shown in Fig. 1. Within an outer shell *A* is placed the nozzle *B* through which the steam rushes past the controlling valve *C*. The velocity of the steam carries the surrounding air with it and creates a suction through the openings *D* and a consequent vacuum in the air chamber *E*. This mixture of steam and air rushes through a second nozzle *F* and sucks more air through the openings *G*, leading into the air chamber *E*. The steam, together with the air displaced, passes off through the exhaust pipe *H*.

The amount of air displaced depends on the construction of the chamber and on the quantity and velocity of the steam rushing through it. The opening *I* in the air chamber where the air line is attached, connects the suction line with the rest of the system through a back-pressure check valve (not shown), its duty being to prevent a back-rush of air through the chamber when the steam is shut off. In order to collect all the dust, dirt, etc., picked up by the sweepers and prevent clogging or interference with the operation of the sweeper, this dust is collected in a dry dust-accumulating tank from which the air is sucked by the ejector and to which it is fed by the lines of sweepers.

It must be noted that this sweeper was intended for operation with four lines of hose and is designated as a four-sweeper type. Therefore, to the accumulating tank were connected four valves to each of which was connected a 100-ft. length of hose and mop (sweeper) for cleaning purposes. The sweepers consist of a slotted air-inlet head connected with a suitable hollow handle in which is a valve to close the flow of air when not in use.

VARIATION IN ECONOMY

The economy of vacuum sweeping is not the same at all pressures, but little attention seems to have been given this point by the modern designers of the cheap commercial sweepers. Experiments conducted by Prof. Hallock, of Columbia University, determined the most economical pressures for sweeping to be between 9 and 13 in. of mercury.

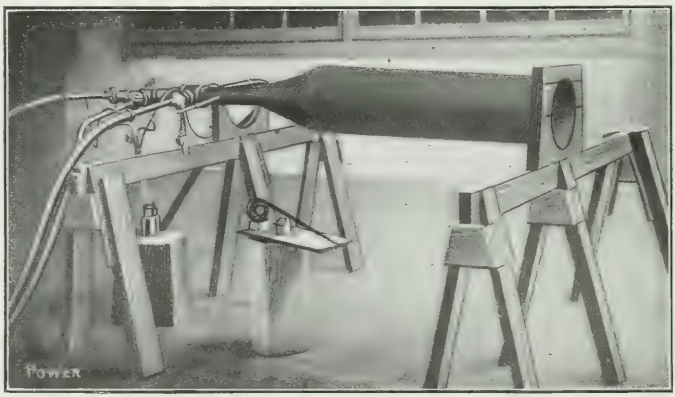


FIG. 2. MEASURING TUBE

TESTS

The ejector subjected to this test was

four sweepers mentioned with a vacuum pressure of 11 in. To afford steam economy when the full load was not on the ejector, a small plunger-type valve was connected which would decrease the steam supply on the ejector when the pressure rose too high and open it should additional load be put on and the pressure fall. This valve adjustment would not regulate closer than 4 in. of mercury, so it was blocked open and all regulating during the tests done by hand. With a steady load, however, the ejector required little or no regulating.

The tests on this ejector were made with two objects: to determine the quantity of air displaced under ordinary working conditions with a four-sweeper load; and to determine the steam consumption at various steam and vacuum pressures under ordinary working conditions and also for various other loads. The quantity of air displaced per minute was determined with a four-sweeper load for 9, 10, 11, 12 and 13 in. of vacuum in the accumulating tank, although 11 in. was considered the average working pressure carried. When the air displaced by four sweepers at these pressures is known, it would naturally follow that the displacement of a greater or lesser number of sweepers would be in direct proportion to the number of sweepers used.

Steam-consumption tests were made at full load with steam pressures ranging from 80 to 130 lb., with a variation of 10 lb. between each test; also, the tests were conducted at each of the vacuums mentioned. Furthermore, in order to determine the steam consumption at less than full load, tests were conducted with only one, two and three sweepers operating.

In order to have conditions as nearly standard as possible, each sweeper was connected with the ejector by a 100-ft. line of hose, care being taken to see that all lines and joints were air-tight. Moreover, each mop was placed as under working conditions, with the slot against a carpet so that the maximum amount of air would be drawn through the fabric of the carpet. In order to determine the actual vacuum pressure at each of the sweepers, a manometer tube was attached at the junction of each sweeper and hose, the readings being recorded in inches of mercury.

Table 1 shows the vacuum pressures in each sweeper for certain tank pressures and also the average which was determined for all four sweepers.

An attempt was made to equalize the readings by adjusting the position of the sweeper on the carpet, but the inequalities remained. These were probably due to slight differences in the width of the absorbing slots of the sweepers and also to differences which may have existed in the frictional resistances in the different lines of hose.

There were no readily obtainable air meters which would measure so great a quantity of air, and for this reason another method was devised, employing the principle that the velocity of air passing through an opening together with the

TABLE 1. VACUUM, INCHES OF MERCURY

At Tank	Hose No. 1	Hose No. 2	Hose No. 3	Hose No. 4	Average
13	8.54	6.37	9.75	8.88	8.38
12	8.00	6.00	9.12	8.25	7.84
11	7.37	5.43	8.30	7.62	7.13
10	6.75	5.00	7.62	6.94	6.58
9	6.12	4.62	6.88	6.37	5.99
8	5.42	4.12	6.25	5.75	5.38

area of the opening determines the quantity flowing. Therefore, arrangements were made to determine the velocity by means of an anemometer, so the tube

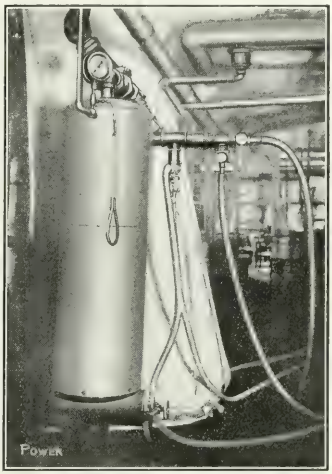


FIG. 3. ACCUMULATING TANK WITH HOSE CONNECTIONS

for measuring the volume was constructed as shown in Fig. 2. This consisted of a sheet-iron cylinder 9 in. in diameter and 36 in. long, one end being drawn down and fitted to the piping connections, which were duplicates of the valve connections used to attach the hose to the tank. Into the side of this cylinder was fastened a glass U-tube for the purpose of reading the pressure in inches of water at this point. A Biram's portable anemometer was used for determining the air velocity.

The anemometer was calibrated before starting the test by noting its speed for each vacuum pressure, the quantity of air passed at these pressures being found by connecting the anemometer with a large air-storage tank from which the air was allowed to escape rapidly and at the same time, by means of the volumes, and pressures could be accurately measured. By means of a controlling valve the air pressures in the anemometer tube, as indicated by the manometer, were kept constant and equal to the results which had been determined for different vacuum pressures when the tube was operating in the reverse direction, the apparatus having been arranged in such a way that the results would be reversible. Correction was determined and made in each test for the reversed position of the anemometer. Under these circumstances, it was found that the four lines of hose were passing quantities of air as shown in Table No. 2.

TABLE 2. AIR DISPLACEMENTS

Vacuum at Tank	Air Displaced, in Cubic Feet per Minute
13	90.1
12	89.1
11	87.8
10	86.4
9	84.2
8	80.9
7	79.1

Had a large enough surface steam condenser been at hand it would have been an easy matter to have condensed the steam, corrected for the humidity of the outcoming air and so determined the steam consumption of the ejector, but owing to the lack of this appliance it was necessary to determine the amount of steam fed to the ejector and to fire a separate boiler for this purpose. In this way it was possible to very accurately determine the steam consumption of the ejector.

Table 3 shows the steam consumption in pounds per hour for the ejector at different steam and vacuum pressures, and also the equivalent boiler horsepower based upon a feed-water temperature of 100 deg. F.

TABLE 3. STEAM CONSUMPTION

Steam Pressure in Boiler, Lb per Sq In		Steam consumed per hour for varying vacuum pressures maintained in ejector				
		13 in.	12 in.	11 in.	10 in.	9 in.
80	Lb	720	680	630	580	516
	Boiler hp.	24.2	22.7	21.1	19.3	17.2
90	Lb.	700	650	600	540	470
	Boiler hp.	23.4	21.8	20.1	18.1	16.1
100	Lb	680	620	550	495	439
	Boiler hp.	22.8	20.8	18.5	16.6	16.0
110	Lb	648	606	532	476	414
	Boiler hp.	21.8	20.3	18.8	16.5	14.3
120	Lb	654	620	560	490	426
	Boiler hp.	22.0	20.8	18.8	16.5	14.3
130	Lb.	628	598	550	480	416
	Boiler hp.	21.2	20.2	18.5	16.2	14.0

It will be observed that the steam consumption rises very perceptibly at the pressure of 120 lb. Just why this should be, was hard to account for, but it was evidently due to the ejector causing eddies or other losses at this particular pressure. Curiously, the consumption fell again when the pressure rose to 130 lb., but in some cases it did not fall as low as before the increase in pressure. This shows the much greater efficiency of the ejector when working at certain pressures than at others, and would tend

to indicate that under certain exceptional conditions it would pay to run the steam through a throttling valve if the pressure were high, before it was fed to the ejector.

It might be suspected that if this occurred only in one or two instances, it was due to an error in testing; but it will be noted that this rise in steam consumption occurred at all vacuums and all the tests, which were carefully repeated and checked, indicated this increase.

In order to test the relative efficiencies of the ejector with loads of less than four sweepers, tests were made with three, two and with a single sweeper working at the end of a 100-ft. length of hose. Under these circumstances, the tests were made with an average vacuum of 11 in. of mercury and a steam pressure of 100 lb. From the results of these tests the steam consumption may be approximated for any other steam pressure and for a varying number of sweepers by referring to the former steam-consumption tests. The steam consumptions for the different loads are given in Table 4.

TABLE 4 STEAM CONSUMPTION AT VARYING LOADS

Number of Sweepers	Steam Consumption, Pounds per Hour
4	550
3	514
2	480
1	450

In view of the fact that there is so little decrease in the steam consumption to maintain a given vacuum with fewer sweepers working, it is probable that a considerable amount of the steam used went to maintain the vacuum in the ejector cylinder, and possibly if other tests could have been made with varying outlet shells, it would have been found that the efficiency could be materially increased at lighter loads.

In comparing these with other tests which may have been conducted on a pump or cylinder type of vacuum cleaner, due allowance must be made for the fact that all values of air displacement given in these tests are for cubic feet of free air and not for rarefied air, while if a test is conducted on a regular vacuum-pump cylinder, due allowance must be given for the rarefied condition of the air which the pump is handling, so that it really must handle from 20 to 50 per cent. more volume in order to exhaust an equal volume of free air.

New York City has established a fire-prevention bureau, and the Board of Estimate has made an allowance of $200,000 for its maintenance. Included in the bureau are an assistant electrical engineer at $3000; two electrical inspectors at $1800 each, and an assistant chemist at $1800. It is not known whether the appointments will be from civil-service lists.

Engine Foundations

By R. B. Dale

Engine foundations perform two functions; they hold the engine bed rigidly in place and they absorb vibrations. The foundation must, therefore, be heavy and bulky and it must have a substantial and firm bearing in the earth. Concrete is by far the most available and best suited material for this purpose. It is not only a comparatively inexpensive material but it is also exceedingly convenient to handle and to mold into the necessary form. Moreover, with intelligent supervision, the foundation may be built without the use of skilled labor. However, sufficient time must be allowed for the concrete to set before a load is placed on the foundation.

The engine base is held to the foundation by means of anchor bolts. These are mild-steel rods several feet long with a square nut and anchor plate at one end and a hexagon nut at the other. The foundation is usually built and the anchor bolts set in the locations indicated for them on the engine builder's setting plans before the engine has been shipped so that the foundation may be ready to receive it when it arrives. The anchor bolts are hung from a template which is securely fastened to the top of the forms for the concrete, and the anchor plate is completely buried in the concrete. A small wooden box, tapering from the lower end to the upper end, is made to surround the anchor bolt; this allows for a slight adjustment of the bolt so that it will fit into the cored holes provided for it in the engine bed. This precaution is necessary because it is almost impossible and, in any case, too expensive, to set them so that an accurate fit is obtained.

When the engine arrives and after the concrete has properly set, the engine is moved to its foundation where it is set into position. Small iron wedges are driven under the edge of the engine bed until the engine is level, thus leaving a space of ½ in. or more between the engine base and the top of the concrete. The hexagon nuts on the upper ends of the bolts are then tightened up, after which a cement grout is run under the engine base and allowed to set. When the grout has set the wedges are removed and the nuts on the anchor bolts are again tightened as much as possible.

In order that the foundation may perform to the fullest extent its function as an absorber of vibrations, the vertical hole through which the anchor bolt passes is not filled with grout. This allows the bolt to stretch or elongate throughout its entire length whenever subjected to shock. It may be said to act somewhat in the manner of a spring. If the anchor plate is of ample area, no advantage in holding-down force is obtained by grouting the bolt for the whole of its length as the bond between the steel and the concrete is comparatively slight in effect. Any lateral movement of the engine on the foundation is prevented by the force of friction which exists between the engine bed and the top of the foundation. The greater the initial tension in the bolts, the greater is this resisting force. If a slight movement should take place this resisting force would increase enormously because the tension in the bolts would increase as they are stretched to accommodate themselves to the new position. Shearing strains which are liable to occur in the bolt between the top of the foundation and the engine bed, if it is completely bedded in the grout, are also prevented.

It is sometimes necessary to change an old foundation to accommodate a new arrangement, such as the compounding of low- and high-pressure steam cylinders, to increase the power of the engine. Whenever it is necessary to set an anchor bolt in an old foundation, the difficulty may be met in one of two ways. In the first method a hole is drilled in the concrete slightly larger in diameter than the bolt to be used and to the proper depth. A bolt is then prepared by cutting a slot in one end lengthwise of the bolt and about six or eight inches long. This slot is then fitted with a wedge of hardened steel held in place by a pin of soft copper or other soft metal. The bolt is lowered into the hole and struck several hard blows on the upper end with a heavy hammer. This shears the soft metal pin and drives the wedge into the slot, thus enlarging the diameter of the bolt at the lower end. The bolt is then grouted into the hole and the nut is tightened to complete the work.

In the second method a hole is drilled for the bolt as before. A second hole is then drilled laterally through the side of the masonry to meet the first hole and this is enlarged sufficiently to take the standard anchor plate. The work is completed in the customary manner, precautions being taken to grout the anchor plate to a firm bearing in the old concrete. The first method is cheap and simple, although there is no certainty as to what happens in the bottom of the hole. It also has the disadvantages of the grouted bolt previously mentioned. The second method, while it is more troublesome and expensive, is the more reliable and should be used in preference to the first.

The reciprocating engine, since the tendency to produce vibration is greater than in the case of the steam turbine, requires a comparatively heavy foundation. In some cases and in peculiar locations this advantage of the turbine may be so great that the choice of equipment is strongly influenced in its favor. The heavy foundation is expensive to build and, in the case of large units, the cost of the foundation forms a large percentage of the cost of installation.

Discharge Capacity of Safety Valves

A series of tests upon pop safety valves of the locomotive and inspector types to determine the discharge under 200 lb. steam pressure with certain fixed lifts.

The February issue of *The Journal* of the American Society of Mechanical Engineers contains the results of some tests made upon Crosby safety valves by Prof. E. F. Miller, of the Massachusetts Institute of Technology.

The tests were made to determine the discharge capacities of 3- and 3½-in. locomotive pop safety valves, Fig. 1, at varying lifts under 200 lb. steam pressure and of corresponding sized inspector valves of the flat-seated and bevel-seated types, Figs. 2 and 3, under 100 and 150 lb. steam pressure. In each case the spring was replaced by a spindle and the valves were set a definite distance from their seats. In order to avoid unequal expansion, the metal of the valve body and that of the spindle were made the same in the case of the locomotive valves; and the difference in expansion was similarly obviated, as far as possible, in the inspector valves.

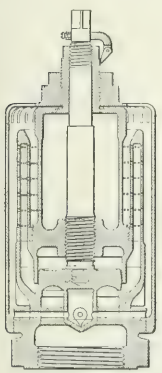


FIG. 1. MUFFLED LOCOMOTIVE TYPE

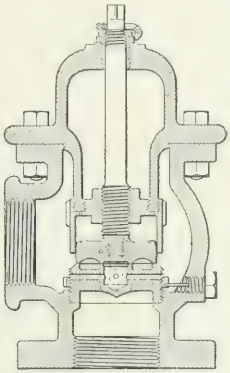


FIG. 2. FLAT-SEAT INSPECTOR TYPE

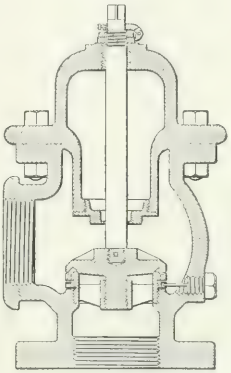


FIG. 3. BEVEL-SEAT INSPECTOR TYPE

Connection was made to the boilers through a 5-in. line and all the discharge was condensed in a surface condenser and weighed.

The additional lift due to the yielding of the metal because of the presence of steam pressure on the under side of the valve was determined in each case by placing the valve in a testing machine and subjecting it to a load corresponding to the steam pressure, the movement of the valve with relation to its seat being measured by a micrometer caliper.

The results of the tests are plotted in Figs. 4 and 5. As a result of these tests the muffled locomotive pop safety valve is now made as shown in Fig. 6.

In an addendum to Prof. Miller's paper, Mr. A. B. Carhart, of the Crosby Steam Gage & Valve Co., makes some general comments regarding pop safety valves. Quoting in part these remarks, he says:

"Pop safety valves were invented about 60 years ago and about 30 years later were perfected in this country and went into general use. Broadly, the invention consists of an addition to the disk of the valve so that when the valve is closed the addition is excluded from the action of the steam. However, when the valve opens the outflowing steam acts upon it and with the initial force causes the valve disk suddenly to rise higher and the spring to be compressed more than it would be with a force due to the steam pressure acting upon the original area only.

"The bevel-seated valves (Fig. 3) generally have this additional area at the periphery of the disk, outside of the seat, where it forms a chamber with a more or less contracted outlet at the extreme lip of the valve, through which all the steam must pass after escaping over the seat before it reaches the open air.

"As the seat is formed at an angle of 45 deg. to the vertical, the passage between the seat and the disk faces, when the valve opens, is diagonally upward, and what is called the lip of the valve is so related to this seat that the steam is forced to impinge directly upon it before being deflected downward toward the bottom of the chamber where it reacts. The effect of the impact upon the lip of the valve is increased by the expansive force of the steam acting in the lip chamber on account of the partial and momentary confinement before it passes into the open air. Sometimes openings are made through the lip or in the floor of the chamber, through which the steam escapes and so reduces the pressure within the lip chamber that the valve disk will not lift too high.

"Annular valves have the additional area located at the center of the disk and within the outer seat. This area is excluded from the action of the steam when the valve is closed, by means of an inner seat, but is acted upon directly by the steam when the valve opens. The disk is simply a flat cover for the valve base and has two concentric seats in the same horizontal plane. The central area of the disk, which is not exposed to the steam when the valve is closed, covers a well which communicates to the outer air through four hollow arms radiating from it out through the sides of the valve body.

"When the valve opens, the steam is discharged directly across the outer flat

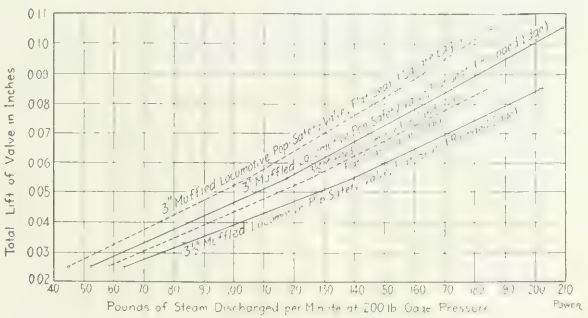


FIG. 4. RESULTS OF TESTS ON LOCOMOTIVE TYPE OF POP SAFETY VALVE

seat, and there is also a separate additional flow over the inner seat into the central well and out through the four hollow arms. The openings through these arms are controlled by a sleeve, threaded on the valve body, so that it may be turned upward or downward as desired. If it should close the open ends of the hollow arms, preventing the escape of the steam through the central well, the reactionary effect upon the disk to lift it against the spring would be greater than if the openings from the well were unobstructed; and by locating the sleeve at intermediate points the lift of the valve can be varied.

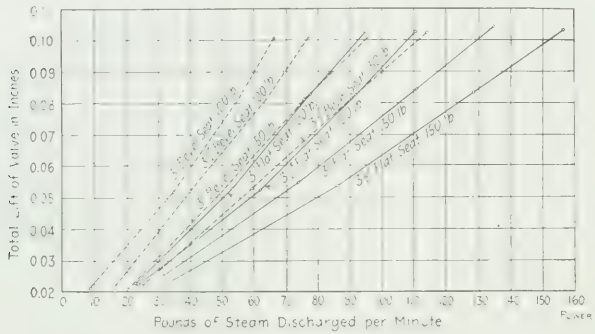


FIG. 5. RESULTS OF TESTS ON INSPECTOR TYPE OF POP SAFETY VALVE

"In bevel-seated valves the disk is ordinarily guided vertically so that it will return properly to its seat when the valve closes, by means of four or more radiating wings or vanes extending from

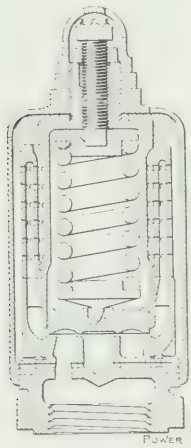


FIG. 6. MUFFLED LOCOMOTIVE POP SAFETY VALVE AS NOW MADE

the face of the disk in the steam space and bearing against the sides of the inlet or throat of the valve. But in the annular valve there are no guides or wings attached to the disk, which is simply a flat member having the truncated form of the central zone of a sphere.

"This is placed in a cylindrical chamber outside and above the steam space, and there it lifts or moves freely as acted upon by the steam against its lower face and by the opposed spring which presses upon it at its center. The contact between the chamber and the spherical part of the disk is the least possible, which permits universal movement of the disk without possibility of cocking or sticking, and yet insures that the disk will return accurately upon its seats when the valve closes."

Superheat and Vacuum Corrections in Steam Turbine Practice

In a valuable and interesting paper read before the Institution of Electrical Engineers at Manchester, on Jan. 16, K. Baumann gave what is believed to be the most complete set of correction curves for superheat and vacua which have yet been published.

He pointed out at the same time that too frequently turbines using different superheats are compared together, to the great advantage of that having the higher superheat. The percentage gain by a given amount of superheat is, moreover, nearly the same, whatever the initial pressure and whatever the vacuum. On the other hand, vacuum corrections vary considerably, he remarks, with the design of the exhaust end of the turbine.

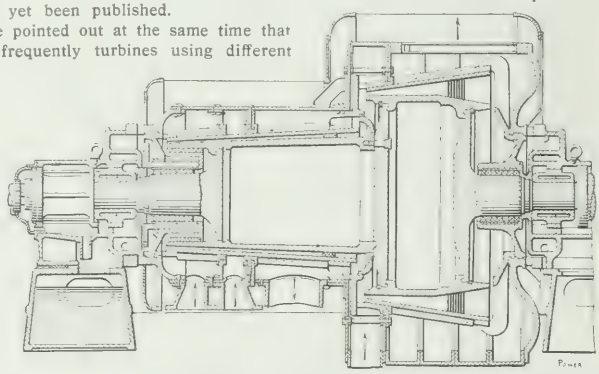
With the present design of high-pressure Westinghouse impulse turbines, he states that the following figures show the improvement in steam consumption with different vacua. An increase of vacuum from 26 to 27 in. diminishes the steam consumption by 4 per cent., from 27 to 28 in. diminishes the consumption by 5 per cent., and from 28 to 29 in. it diminishes the consumption by 6 per cent.

With exhaust-steam turbines the consumption continuously decreases, the thermodynamic efficiency falls off as follows: Increasing the vacuum from 26 to 27 in. diminishes the efficiency by 1 per cent., from 27 to 28 in. by 1 per cent., from 28 to 28½ in. by 1 per cent., and from 28½ to 29½ in. by 2.5 per cent. With exhaust-steam turbines the steam consumption improves by 11.5 per cent. with an increase of vacuum from 26 to 27 in., by 13 per cent. for an increase from 27 to 28 in., and 14.5 per cent. for an increase from 28 to 29 in. In these cases it should, however, be stated, that for the higher vacua exhaust turbines are designed with a higher "coefficient."

Mr. Baumann also gives pressure correction curves by which the actual pressure in the steam chest can be reduced to an equivalent standard pressure.—*Engineering.*

Ferranti's Turbine

In order to prevent distortion, and thus to permit drum turbines to run with closer clearances, Ferranti proposes to carry the stationary blades upon a stator entirely separated from the outer casing, or to provide separate organs to fulfill the different functions now performed by



FERRANTI'S TURBINE, WITH STATOR FREE FROM CASE

the casing alone, so that the stator is relieved of influences tending to produce unequal extension. The accompanying sectional drawing showing the proposed arrangement is reproduced from *The Mechanical Engineer.*

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

Several hoisting engineers are visited, and although some have clean, pleasant surroundings, others are obliged to work in dark, dirty engine-rooms.

Hoisting engineers receive practically the same pay, regardless of their ability, condition of plant and amount of work performed.

The more I saw of Hunter the better I liked him. Not only was he a companionable fellow, but he seemed to know his business, and I soon had a suspicion that he held a higher position than that of hoisting engineer, if the truth were known.

We met at breakfast the next morning after he had related his experience with overwinding and, as the day was fine, he proposed that we visit a few hoisting engineers in the vicinity, to which proposition I readily agreed.

During our ride to the mines in a street car the subject of hoisting engineers was broached and Hunter discoursed at length upon how engineers had made mistakes when the signals had been confused or the machinery had become deranged.

"There is as much difference in engines as there is in the men who operate them," said Hunter, as the car started. "Some men are always on the outlook for anything that may get out of order and others seem content to let matters take care of themselves, with the exception of an occasional inspection. The fact is, many hoisting plants are so dark and so dirty that an ordinary inspection will not disclose the defects."

Mine-car Operation

By this time the car had reached the end of the line and, alighting, we crossed a field and came to the first anthracite colliery I had ever visited. The cages in the two shafts were hoisted in rapid succession and, upon reaching the surface, the cars, which were filled with huge chunks of coal, were drawn up an incline by means of a barney-car and cable. After the coal had been dumped into the breaker rolls the barney-car was drawn back over the incline or plane and passed on its own track to the ground level, while the mine car returned to the ground level by taking the upper track.

As each empty car returned to the ground level, the section of track where the upper joins the lower track or incline lifted so that the loaded car was given a clear passage to the breaker. Then the movable section of track was lowered into place and the empty car would take the top instead of the lower track on its return passage. This method of handling the mine cars prevented congestion and kept the empty cars out of the way of those which were loaded.

The rapidity with which the shaft cages were handled greatly interested me, and I soon switched Hunter's conversation to this subject.

"You were speaking about inspecting hoisting machinery," I said, as we left the engine room and started for another which showed above a culm pile some distance away.

Need for Thorough Inspection

"Yes, the engineer in charge of a hoisting engine should make at least one thorough inspection each day. The cables require especial attention and the valve-gear links and auxiliary gear should also be carefully inspected. How a man is going to detect cracks and other defects in machinery which is covered with a thick layer of grease and coal dust is more than I can understand.

"But," I protested, "the engine rooms we have visited have not been so very dirty. They may not have been as shiny and clean as some high-grade power plants that I have seen, but for a coal mine are they not in as good condition as could be expected, considering the surroundings?"

"I admit that some are in fair condition," answered Hunter, "but I am going to show you a few engine rooms that are about as near perfection as commercial conditions will warrant—then some others."

"I suppose the attitude of the company determines the condition of the engine rooms to a considerable extent," I remarked, as we neared No. 9 colliery of the Pennsylvania Coal Co.

Ideal Conditions

"It does, as I will show you," replied Hunter, as he opened the door of the

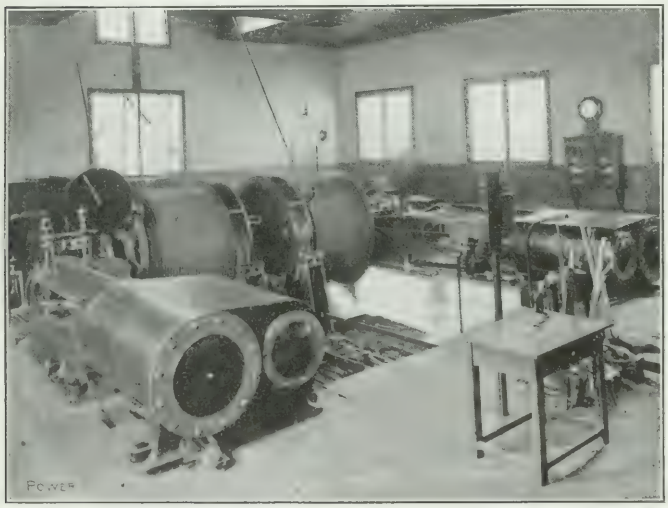
We Crossed a Field and Came to the First Colliery I Had Ever Visited

engine room at the Leadville shaft of the colliery. And indeed he did, for not only were the walls of the room painted a cream color, with a dark-red wainscoting, but the floor was also painted and varnished; the engines were painted a maroon color and all was as clean as it is possible to keep it. The ceiling was sheathed and oiled, so that it reflected the various apparatus in the plant.

Hunter introduced me to the engineer on duty who, on account of a slight accident to a slope engine, was not very busy and, therefore, had a little time in which to talk.

He told me that the company made regular inspections of its plants and rated the standing of each engineer according to the conditions in which the plant was found. He stated that his last mark was 99 per cent. perfect, and from the condition of the machinery and its surroundings I judged that he was the "top-notcher" of the company's hoisting engineers.

"This company," said Hunter, "encourages, and expects, its engineers to keep their plants in good order. I believe the company has the right idea, for a man can do better work under such surroundings as we find here than he can when the conditions are filthy."



A Well Kept Engine Room, the Engineer of which Rated 99 per Cent. Perfect

My visit to the various hoisting engineers showed me that I had a mistaken idea as to their standing. Those who are in charge of the better class of hoisting engines were bright, intelligent men, and I found out afterward that several of the outside superintendents I afterward met had at one time been employed as hoisting engineers. This goes to show that there is an opportunity for advancement for the engineer if he prepares himself to fill the position when the opening presents itself.

Where It Was Different

The next plant visited was about as dirty and as nasty as one could imagine. No attention was given to cleanliness and the engineer looked no more attractive than his engine. Grease, oil, coal dust, oil-waste and rubbish littered the floor, and the windows were thickly covered with grime, which added to the dinginess of the place.

Hunter grinned as he pushed me through the open door, and the grin broadened as the engineer started up and the clatter and grinding of the gears began. The engineer, however, was evidently at home in such surroundings, and he showed no signs that he was conscious that neither he nor his engine room was unpresentable. Compared with that of the engineer we had last visited, his standing would have been several degrees below zero.

"Let's get out of here!" I shouted in Hunter's ear, as a train of empty coal cars rattled past, and without waiting for a reply I made for the door, followed by Hunter.

"That is the worst I know off," he grinned. "I don't think there is another like it; if there is, I don't know where it is located."

"There must be a difference in the salaries of some of these men," I suggested, as we made our way toward a colliery farther down the valley.

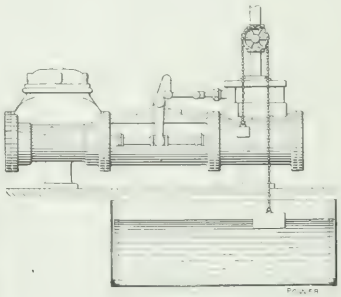
Well-doing Is Its Own Reward

"Well, there isn't; a hoisting engineer is a hoisting engineer in the eyes of the company. One man may be twice as efficient as another; but he don't get twice the pay. The only reward he gets is the knowledge that he is doing his work right, is keeping his plant clean, and that he stands a chance of promotion. It is a safe bet that our last engineer will not be selected for a position higher up."

We returned to the hotel that night tired and hungry, and after dinner we were well content to retire to our rooms after a profitable day spent among hoisting engineers.

Automatically Operated Duplex Pump

In mine practice it is not always convenient to discharge the cooling water used in the cooling jackets of air compressors, where it will run to some convenient place out of the way. In one instance it was necessary to discharge this



Valve Operated by a Float

cooling water into a tank under the floor of the compressor room.

In order to keep the water level in the tank uniform, a pump was used, which discharged the water at a distant point. The steam pipe of the pump had a globe valve, the stem of which was fitted with a sprocket wheel. A sprocket chain ran over this wheel, one end being attached to a suitable weight and the other to a float in the tank which was directly under the pump. As the height of the water increased or decreased, the float opened and shut the valve, so that the water level was kept practically constant.

Water Power Law Upset

The Wisconsin Supreme Court, in a decision issued Jan. 30, held the water-power law enacted by the 1911 Legislature unconstitutional. The law sought to vest in the state all rights to water power heretofore held by corporations and individuals, subject only to lease. The decision was the unanimous conclusion of the justices.

The court declared the law involved the wrong conception of the state's interest in the power element of navigable waters and the capacity to deal with it.

Notes on Metering Coal

Some interesting notes upon metering coal have recently been compiled by the O. D. Havard Co., maker of the Havard coal meter. This meter was described in our Mar. 29, 1910, issue and consists essentially of a spiral vane placed centrally in the vertical part of the coal chute. The vane is caused to rotate as the coal passes down the pipe and these rotations are recorded on a chart or dial.

For the accurate operation of this device with steam sizes of hard coal, the pipe must be completely filled with coal at the meter and the cross-section of the coal must move uniformly. If the coal should fall on the meter in a shower, the revolutions of the vane will bear no fixed relation to the amount of coal passing, and when the cross-section of

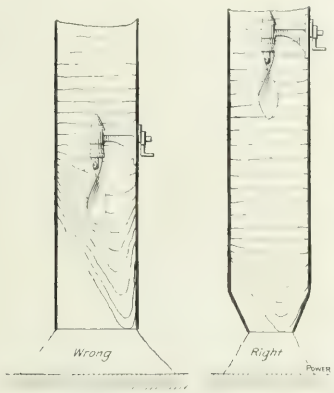


FIG. 1. WRONG AND RIGHT WAYS FOR COAL TO STRIKE METER VANE

the coal does not move uniformly, there will be a shearing across the vane, which will affect the accuracy of the reading. This condition is illustrated in Fig. 1. Furthermore, the meter should always be placed as far as possible above any influence tending to disturb the stream of coal, such as a branch, sharp turns or an open valve in the line. Also, it is important to have the pipe as nearly vertical as possible.

In the matter of soft coal the requirements are said to be more exacting on account of the varying sizes of the lumps and because it does not flow as freely as hard coal. This is overcome by decreasing the diameter of the vane, increasing its length and protecting it from the impact of large lumps by a conical shield placed at the top, as shown in Fig. 2; it having been found that without this shield the lumps struck the edges of the vane and caused it to stop until the lump had descended.

An idea of the accuracy of these meters may be gained from the following figures taken from the records of fourteen meters in one plant:

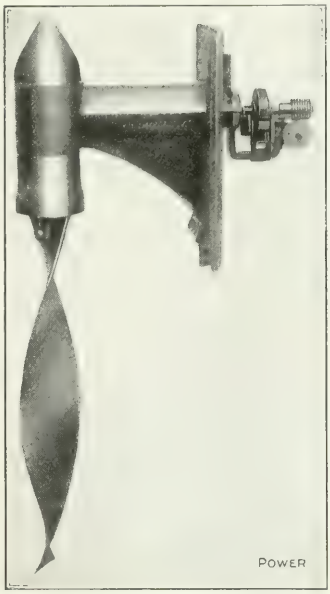


FIG. 2. METER DESIGNED FOR MEASURING SOFT COAL

	Meters, tons	Inventory, tons	Variation, per cent
Jan.	3,443	3,364	+2.35
Feb.	3,086	2,904	+6.25
Mar.	2,997	2,922	+2.50
Apr.	2,573	2,495	+3.13
May	2,414	2,439	−1.03
June	2,364	2,341	+0.98
July	2,662	2,791	−4.63
Aug.	2,846	2,880	−1.18
Sept.	2,618	2,604	+0.54
Oct.	2,437	2,441	−0.164
Nov.	2,945	2,824	+4.3
Dec.	2,975	3,080	−3.4
	33,360	33,085	+0.83

Combustion of Pulverized Coal

In a paper read before the American Institute of Chemical Engineers, L. S. Hughes summarized the advantages of using pulverized coal and discussed the difficulties encountered in its use. The chief difficulty has been the destruction of the firebox and crown-sheet. Both bricks and steel "melted" little by little, which effect has been attributed to the high temperature of the flame produced by pulverized coal.

When the temperature of the flame was reduced, the grate bars, crown-sheet and walls of the firebox became covered with a vitreous, adherent coating of slag or clinker. This clinker is similar to the slag produced in blast furnaces and is evidently formed by the action of the silica of the ash with iron oxide forming a complex fusible silicate. The silica would also act on the firebrick by reducing its melting point.

The remedy suggested and tried consisted in introducing powdered limestone with the coal dust. A simple air-blast injector fed the coal into the firebox and a small amount of limestone, roughly equal in weight to the ash of the coal, was introduced with it. Immediately the character of the ash formed changed from a sticky shower to a dry, pulverulent dust which displayed no tendency to cohere or clinker in any way.

Large Turbo-Compressors

Our English contemporary, *Engineering*, publishes in its issue of Dec. 15 a description of several turbo-compressors built by Pokorny & Wittekind, of Frankfort-Bockenheim. One of these, installed at the Reden mine, near Saarbrücken, in 1909, runs at 4200 r.p.m., handles 247,000 cu.ft. of air per hour, and delivers it at a pressure of seven atmospheres absolute, about 100 lb. per sq.in.

Another, installed in Westphalia, runs also at 4200 r.p.m., has a capacity of 353,000 cu.ft. of free air per hour, delivered at a pressure of eight atmospheres, or 118 lb. per sq.in. The isothermal efficiency of the compressor varies between 64 and 65 per cent., and the steam turbine works with exhaust steam at efficiency of about 68 per cent., and with boiler steam at an efficiency of about 66 per cent. There is also a 4000-hp. electrically driven compressor for the Rand mine to handle 1¼ million cu.ft. of air per hour at a pressure of 128 lb. per sq.in., with an efficiency of nearly 68 per cent.

Utilizing Ontario's Peat Bogs

It is announced by the Canadian government's mine department, reports U. S. Consul H. A. Conant, that the associated manufacturers at Brantford, Ont., have become so convinced that the air-dried peat method employed by the mines branch can be made a commercial success that they have contracted with the government to continue the work at Alfred, Ont., and will spend over $50,000 in trying to improve peat machines. This action was decided on only after a thorough investigation. The machine to be used will have a capacity of 60 to 80 tons per day, as compared with the 30 tons the government turned out.

The government experimental plant at Alfred exhibited samples of machinery and of peat ready for market at the Ottawa fair. A thousand tons of peat were made up, which was sold at $3.25 a ton. The orders came with such a rush that the supply was soon exhausted. The peat was used in parlor grates, in kitchen ranges, and in furnaces. It burns to a fine ash, there being practically no residue, and is much cheaper than coal.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Comparison of Gas, Oil and Steam Motive Powers

By R. E. Mathot

It may be stated, as a principle, that every system of motive power is good and reliable, provided it is properly applied in view of meeting the requirements of each particular case. It would not be wise, for an example, to install a costly gas plant in a sugar mill needing an enormous quantity of steam and having a very short manufacturing season of a few months. For similar reasons, the cost of operating a Diesel engine plant would be extravagant in countries located far from the oil fields or in such countries where crude fuel oil is burdened with prohibitive duties.

Besides the foregoing considerations of primary importance there is another one which seems to be too often disregarded by those who have to select a motive power; I refer to the load factor, or the relation between the normal average load and the maximum power the engine is expected to be able to supply momentarily.

The question of space required also must not be neglected, because the cost of the buildings containing the power equipment and fuel depends on it. In this particular the Diesel engine has the advantage over any other kind of prime mover, because it does not require any boiler or producer and the volume of fuel is the smallest.

The accompanying tables show the comparative costs of installation and operation for 3000-hp. power plants equipped with different types of prime mover. In fixing the number of units which are necessary for realizing the 3000 hp. maximum under consideration, I have taken into account different factors derived from practice, such as reliability, allowing the number of spare units to be reduced; margin of power, depending upon the system; influence of load variations upon the fuel consumption; facility of attendance, etc. I have considered four Diesel engines, three of which would be running while, owing to the facility of starting, the fourth engine would be at standstill but ready for service in case of need.

In the producer-engine plant I have reckoned upon five units of 600 hp. each, because this power is easily realized from single-acting, twin two-cylinder engines connected by couplings, with the flywheel in the middle. For some time this kind of engine has met much favor in the manufacturing industry. It is cheaper to build and its upkeep and attendance are simpler than the double-acting engine which seems to be preferable on the Continent for power above 1000 hp. Moreover, the single-acting engine with trunk pistons works better with suction producer gas without requiring the thorough purification necessary in the case of steel works using blast-furnace or coke-oven gas.

I have considered suction producers for feeding the five engines in preference to pressure producers because the former are simpler and less expensive. They are also less cumbersome and of higher efficiency. I have reckoned upon ten producers of 300 hp. each, plus two generators which would constitute the spare apparatus.

Bituminous producers have not been considered because for economic working they involve the installation of a recovery plant for ammonia, tar, etc.

The working dimensions of the engines have been calculated for a margin in power of 10 to 20 per cent.; to this end they should develop the 600 hp. with a mean effective pressure on the pistons of 65 lb. per square inch, although in good modern engines this pressure easily reaches 80 lb.

The German semi-portable steam engines, although units of 800 to 1000 hp. have not been long in industrial use, have proved their remarkable qualities. The self-contained boiler and engine form a compact equipment which needs no expensive foundations. The exceptionally low fuel consumption, which is less than 1 lb. of gross coal per brake horsepower-hour, allows the use of a small chimney. The semi-portable engine has a large margin of power; therefore it is unnecessary, as with turbines or other steam engines, to have spare units.

For the other steam plants I have assumed the installation of one or two additional boilers for the purpose of cleaning or repairing. The Lancashire type of boiler with two or three corrugated internal furnace tubes, without Galloway tubes, has been chosen. This kind of boiler, with its large volume of water, presents the advantage, as compared to the tubular boilers, of a large margin of steam production. It has a high efficiency at the rate of 3 to 3½ lb. of water evaporated per hour per square foot of heating surface and can attain 5 lb. without sensible priming, giving then 8½ lb. of steam per pound of good coal.

For some years, by virtue of the use of corrugated steel flues and plain drop-forged ends of large diameter, these boilers have been constructed for pressures up to 215 lb. per square inch, with heating surfaces as large as 1600 sq.ft. per boiler.

For establishing the cost of operation for each type of motive power, appropriate rates of depreciation derived from practice have been used. In this respect the Diesel engine may be considered on the same basis as fuel-gas engines of good construction, and could be written off within 10 years, while 15 years would be required for semi-portable steam engines and turbines and 20 years for stationary steam engines of the Corliss, Sulzer and piston-valve types.

The costs of upkeep and repairs are not mentioned here, as they depend almost exclusively upon the original quality of construction and workmanship and also upon the character of attendance and supervision. The cost of labor for each type of plant has been taken into account, but these costs are applicable only to Belgium, where wages are relatively low.

COMPARATIVE INSTALLATION COSTS FOR A POWER PLANT OF 3000 HP.

For a Factory Utilizing an Average of 2000 Hp. and a Minimum of 800 Hp. During 300 Days per Year, 24 Hours per Day

Diesel-type Engines		
Four 800-hp. engines at $29,000 each	$116,000	
Foundations, pipings and connections	4,000	
		$120,000
Suction Producers and Engines		
Five 600-hp. engines at $13,200 and ten 300-hp. producers at $2000 each	$86,000	
Two spare producers	4,000	
Foundations, pipings and connections	6,000	
		$96,000
Semi-portable Steam Engines		
Five 600-hp. engines at $17,000 each	$85,000	
Masonry, connections and stacks	3,000	
		$88,000
Turbo-alternators		
Three 750-kw. units at $16,600 each	$49,800	
Foundations and piping	3,000	
Eight Lancashire boilers, 1300 sq.ft. of heating surface each	16,000	
Masonry for boilers	2,800	
Flues and stacks	1,400	
Automatic stokers	2,400	
Superheaters	3,200	
		$78,600

Piston Steam Engines

Two 1500-hp. engines	$30,000	
Foundations and connections	5,000	
Seven boilers of 1300 sq. ft. heating surface each	14,000	
Masonry for boilers	2,400	
Flues and stacks	1,200	
Automatic stokers and heaters	4,800	
		$57,400

COMPARATIVE ANNUAL LABOR COSTS

CRUDE-OIL ENGINES

Four engines require

Two engineers at 13c. per hour	$0.26	
Three laborers at 6c. per hour	0.18	
Total	$0.44	
Per year: 300 days×24 hours×$0.44		$3,168

FUEL-GAS ENGINES

Five engines require

Three engineers at 13c. per hour	$0.39	
Five stokers at 9c. per hour	0.45	
Five laborers at 6c. per hour	0.24	
Total	$1.08	
Per year: 7200×$1.08		$7,776

SEMI-PORTABLE ENGINES

Five engines require

Three engineers at 13c. per hour	$0.39	
Five stokers at 10c. per hour	0.50	
Five laborers at 6c. per hour	0.30	
Total	$1.19	
Per year: 7200×$1.19		$8,568

TURBO-GENERATORS

Three engines require

Two engineers at 15c. per hour	$0.30	
Two stokers at 10c. per hour (The boilers are provided with automatic stokers)	0.20	
Three laborers at 6c. per hour	0.18	
Total	$0.68	
Per year: 7200×$0.68		$4,896

PISTON STEAM ENGINES

Two engines require

Two engineers at 13c. per hour	$0.26	
Two stokers at 10c. per hour (Automatic coal feeders)	0.20	
Three laborers at 6c. per hour	0.18	
Total	$0.64	
Per year: 7200×$0.64		$4,608

ANNUAL EXPENDITURE FOR FUEL

AVERAGE LOAD, 2000 HP. DURING 300 DAYS OF 24 HOURS EACH, GIVING 2000×24×300=14,400,000 BRAKE HORSEPOWER-HOURS PER ANNUM

	Per Year
Diesel-type Engines Consuming about 200 gr. of crude oil per brake horsepower-hour. Russian or Texas oil costs $1.40 per 100 kg., giving a cost of 0.28c. per brake horsepower-hour or $0.0028×14,400,000	$40,493
Producer Gas Engines Consuming at variable load per brake horsepower-hour 400 gr. of lean coal, which costs $3 a ton, or 12c. per brake horsepower-hour; $0.012×14,400,000	$17,280
Turbines At variable load consuming about 6 kg. of steam per brake horsepower-hour, which gives a consumption per brake horsepower-hour of 7.5 kg. of steam=1 kg. of coal at $3.20 a ton, or 0.32c. per brake horsepower-hour; $0.0032×14,400,000	$46,080
Semi-portable Steam Engines Consuming per brake horsepower-hour 520 gr. of semi-bituminous coal at $3.20 a ton or 16.64c. per brake horsepower-hour; $0.1664×14,400,000	$23,962
Piston Steam Engines Consuming 4½ kg. of steam per indicated horsepower-hour or 5 kg. steam per brake horsepower-hour. With a normal evaporation of 7½ kg. of steam per kilogram of semi-bituminous coal, one brake horsepower-hour requires 0.665 kg. of coal, at $3.20 a ton, giving 21.28c. per brake horsepower-hour; $0.2128×14,400,000	$30,643

Considering the plants are supposed to work day and night without interruption, the rates and interests and depreciation have been calculated upon nearly relative short time.

It should be borne in mind that the figures for labor fuel consumption and working apply to Belgium, where they are sensibly lower than in America. For United States said figures should be increased accordingly with the exception of the price of crude oil.

COMPARISON OF THE PRINCIPAL ANNUAL OPERATING COSTS

Type of Equipment	Depreciation Rate	Fixed Charges*	Fuel	Attendance	Annual Total
Diesel engines	15½ %	$18,600	$40,493	$3,168	$62,261
Producer gas	15½ %	14,880	17,280	7,776	39,936
Semi-portable steam	12.9%	11,352	23,962	8,568	43,882
Turbines, etc	12.9%	10,139	46,080	4,896	61,115
Piston engines, etc	11.3%	6,186	30,643	4,608	41,737

*Depreciation plus 5% interest on investment.

Exhaust Pipes for Gas Engines

BY F. B. HAYS

The exhaust from a steam engine can be used for many purposes and is piped from the engine to heat buildings, dry stock, etc. The exhaust from an internal-combustion engine consists principally of carbon dioxide, water vapor and nitrogen, which, combined as they are, are entirely useless for any commercial purposes. As these gases cannot be put to any practical application they should be discharged directly into the atmosphere at the exhaust port of the engine in order to secure the greatest thermal efficiency of the latter. However, this is rarely found practical because of the disagreeable and injurious odors of the exhaust gases, so they are generally piped to some point outside the building containing the engine, for which purpose some form of pipe is used.

As the function of the exhaust pipe is simply to carry off inert products of combustion from the engine, its construction seldom receives any engineering attention, and consequently it is installed in the quickest, cheapest, and most convenient manner possible. The result of this almost always is decreased engine efficiency due to back pressure produced by incorrectly constructed exhaust pipes.

The arrangement of exhaust pipe which produces the least back pressure is that which passes directly from the exhaust port of the engine to the outside of the building, the pipe being a straight "run" extending from the engine cylinder to the nearest external wall. The only back pressure produced by this sort of exhaust pipe is due to the friction between the moving gases and the internal wall surface of the exhaust pipe. A perfectly straight, direct exhaust pipe is seldom found in actual practice, as it forms a barrier from the engine to the wall of the building and occupies space that can generally be employed to better advantage. For these reasons the arrangement shown in Fig. 1 is mostly used, although it is more expensive to construct. This form of exhaust pipe produces great back pressure, due to the sharp turns and the projections of the butt ends of the pipe into the elbow connections. The course of the exhaust gases in this type of pipe is indicated approximately by the arrow heads. Besides the cross-currents shown, eddy currents are also produced by the gases striking the butt ends of the pipes, so that there are three sources of back pressure.

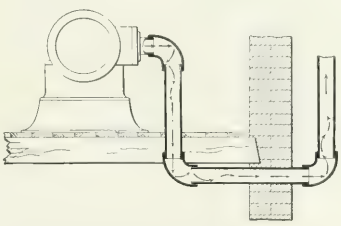


FIG. 1. THE WRONG WAY

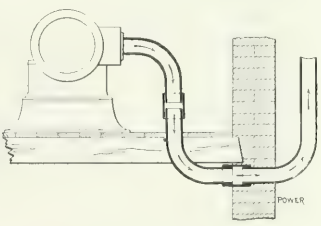


FIG. 2. A BETTER WAY

A type of exhaust pipe which has the advantage of both of the types referred to, without the disadvantages of the second, is shown in Fig. 2. This arrange-

ment allows the pipe to be run under the floor and at the same time eliminates the cross-currents and eddy currents produced by short bends and projecting pipe ends. The construction is evident from the figure. Such an exhaust pipe can be installed almost as cheaply as the one in Fig. 1, and it eliminates all back pressure except that due to wall friction.

The Marine Diesel Engine

Experience with the Diesel engine in marine service has developed the advantage that the air in the engine room is continuously changed by reason of the demand by the engines for air for combustion. The engine-room air, therefore, cannot become stale and unwholesome as long as the engines are running.

This sanitary advantage, however, is accompanied by the disadvantage that the engines do not radiate sufficient heat to keep the engine room warm in cold weather. Builders of oil-power vessels, therefore, are confronted with the problem of devising means for heating their engine rooms!

LETTERS

Timing the Ignition

Earl Pagett's recent letter on a method of timing the ignition of an internal-combustion engine prompts me to describe the method I generally use for this purpose—a method which is not unique by any means but which I do not remember having seen described in POWER before. When the crank is on the inner center, I place an adjustable-angle spirit level on the top of the crank web and read the angle at which the level must be set to the straight-edge in order to get the bubble central. If it is desired that the engine shall fire 20 deg. ahead of dead center, I set the spirit level 20 deg. steeper to the straight-edge, place the straight-edge on the crank web, and turn the engine round until the desired position is reached. Then the ignition trip or timing gear can be adjusted to spark at that point. For valve timing the method of procedure is exactly similar, but for the out-center timings (inlet closing and exhaust opening), it is necessary to obtain a fresh base to work from with the engine at outer center, since the webs are not always machined exactly parallel.

Allowing for the comparatively rough planing or milling of the crank webs, I should prefer this method to Mr. Pagett's, since one obtains the results right away in degrees and avoids the errors introduced into Mr. Pagett's method by the indefinite length of the flywheel circumference and the difficulty of measuring linear distances to the second place of decimals around the rim. An adjustable-angle spirit level will not be found in every plant, I know, but one which will be good enough for the job may be bought very cheaply and once bought, the level will be found to be very convenient for many purposes.

JOHN S. LEESE.

Manchester, Eng.

Starting Suction Gas Producers

There are a great many suction producers in operation throughout the country on intermittent service and putting them in operation again after a night's shutdown constitutes the greater part of the labor necessary to their operation. The writer spent some time in a plant that was in continuous operation, except for eight or nine hours on Sunday, providing electric service to a town of about 5000 inhabitants and our experiences in putting producers in operation after the Sunday shutdown may prove of interest

Upon shutting down on Sunday morning the fires were not cleaned, as was customary in the early morning, but the producers were filled with coal and left standing with the purge pipes open. The first thing was to clean the fires; any clinker that could not go through the grates must be removed and also the ash accumulating around the sides of the producers. Considerable care was necessary to get around the entire circumference without having the fire fall down and block the work. Next, the fires were sliced down from the top and by keeping well to the sides the ash was worked down to the grates.

The producers were then fired, but were not filled, for occasionally it was necessary to add fuel later, to maintain uniform conditions. The fires were then barred from the bottom. In this operation a slicing bar was worked across the grates to loosen and break up any clinker that might not have been reached in cleaning. The center of the fire was then lowered by shaking the grates until it fell through into the ashpits, and the ashes were removed. During these operations one must keep well away from the front of the open doors for there is no draft to remove the gas and it very often puffs out in explosions that are dangerous.

After this preparation, the fires were blown with the blower until the gas burned at the test cocks on the producers, when the valves on the lines to the purge pipe were closed and those on the line to the engine were opened. As soon as the gas burned at the vents at the engines, the blast was turned off and the vaporizers were cut in, care being taken that the vaporizers were in working order and not plugged with deposit. To keep the temperature of the fires down until the vaporizers began to furnish steam, a small amount of water was usually run into the ashpits.

The engines were then started and the scrubber water turned on. Occasionally, when in a hurry to start, only one producer was cleaned and started and the other was cut in later after the engines had been running for some time.

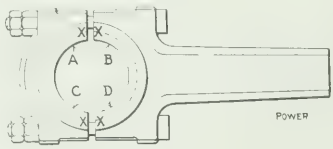
During the week, the fires were cleaned at 4 o'clock, morning and afternoon, and coal was added five times during the 24 hours. The fires were poked once, in addition to the cleaning periods, each day. Our best results were obtained by operating the producers on a light load and avoiding the high temperatures which come with heavy loads. By so doing, there was very little poking and the quality of the gas was kept very uniform.

J. C. PARMELY.

Kewanee, Ill.

An Unusual Cause of a Hot Crankpin

While on installation work recently, I ran across a peculiar case of trouble that developed on an engine which had been installed two months previously. It was a crankpin which would not run cool and which finally burned out four sets of boxes in which experts from both Boston and Roxbury had been unable to locate the cause of the trouble. I succeeded in getting rid of the trouble absolutely in two days of nine hours each and operated the engine three days continuously under full load, with an average temperature at the crankpin of 90 deg., running 24 hours.



CRANKPIN END OF ROD

Upon scraping the babbitt clear of rough places caused by the overheating, I put them back in place, first coating the crankpin with Prussian blue, and turned the engine over through a couple of revolutions. Taking the boxes out showed that they touched the crankpin only from *A* to *B* on top and *C* to *D* on the bottom, although I got a good bearing all around with the boxes held on the crankpin by hand instead of in the connecting-rod. Trying the brasses again in the end of the rod, easing them in by hand, indicated a binding at the edges *X* of the jaws, and caliper measurements showed that the outside diameter of the brasses at the corresponding points was a shade larger than the diameter of the jaw circle. Filing the brasses so they slipped into their seats without forcing remedied the trouble.

D. L. FAGNAN.

New York.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

An Ingenious Emergency Arrangement

By A. S. Specht

In a large manufacturing plant near Boston, electric power is supplied by both alternating and direct currents. The direct current is generated by a local plant comprising reciprocating engines belt-connected to compound-wound generators running in parallel.

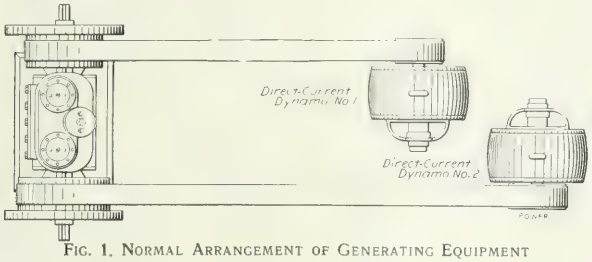


Fig. 1. Normal Arrangement of Generating Equipment

Recently it became necessary to shut down one of the engines for repairs; this was a vertical engine and it had been driving two of the generators, arranged as in Fig. 1. One of these generators could be dispensed with, but not both, because the peak load was too heavy.

There happened to be available an idle alternating-current generator, and, as there was a plentiful supply of alternating current, it was decided to slip this generator into the position occupied by No. 1 direct-current machine and run it as a synchronous motor to drive No. 2 machine, utilizing the engine shaft as a jackshaft, and the same belts.

Some provision had to be made for starting this set and getting the alternating-current motor up to speed and into synchronism, and in order to accomplish this it was decided to run No. 2 direct-current generator as a motor until the alternating-current machine got on the line. Accordingly, connections were made as in Fig. 2, the water rheostat consisting of a tight barrel filled with water and equipped with a couple of old pipe fittings bolted to the leads for electrodes.

At first clear water was used, but it was found to be of too high resistance. Therefore, a bucket of salt was thrown in the barrel and the water stirred up; this increased its conductivity enough to bring the set up to speed. A short-circuiting switch was used to cut out the ammeter in order to prevent it from trying to indicate backward and possibly damaging the pointer.

With one electrode pulled out of the barrel and all switches open, the operation of starting is as follows:

Close the switch short-circuiting the ammeter; throw No. 1 switch up, short-circuiting the series field winding; turn the field rheostat to cut out all of the resistance; throw in the circuit-breaker and the main switch, No. 2; lower the top electrode into the barrel very slowly until it comes in contact with the bottom one, and then close switch No. 3; cut in field resistance until it is up to speed, when No. 2 switch cutting out the water rheostat, and pull the top electrode out of the barrel; then increase the speed of the machine by slowly cutting in the resistance of the field rheostat, to get the alternator into synchronism.

After the alternating-current machine has been synchronized and cut in on its line, running as a motor, trip the direct-current circuit-breaker and pull the main switch (No. 2) out. Turn the field resistance all in and throw No. 1 switch down, which puts the series field winding into normal connection with the equalizer. The machine is now ready to be built up again as a compound-wound generator.

[It is not necessary to open the direct-current leads after the alternating-current machine has been thrown on its line. As soon as this has been done, the field rheostat lever or wheel may be turned two or three points in the "all out" direction and the ammeter put back in circuit; then the rheostat can be adjusted until the ammeter shows no armature current. Throwing the switch No. 1 downward will then put the machine in circuit normally and the field rheostat can be adjusted to make it take its share of the load.—Editor.]

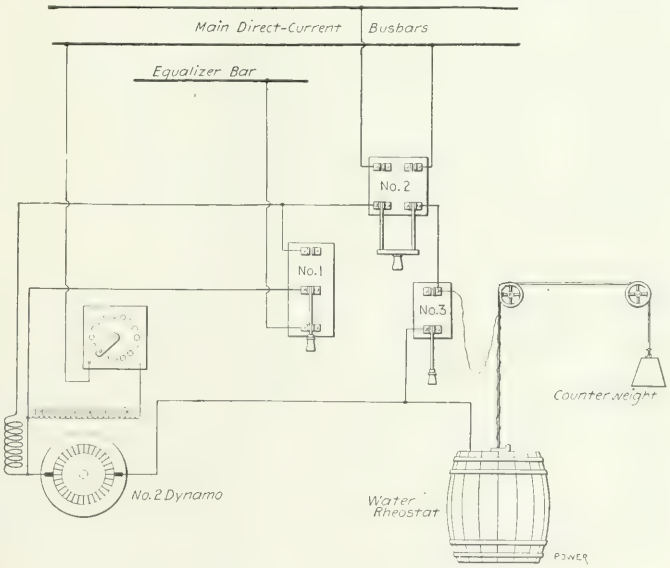


Fig. 2. Emergency Connections for Starting Up

Safety Device for Traveling Cranes

By E. H. Marzolf

It frequently happens around steel mills that men are required to work on the bridge rail of an electric traveling crane. This places them in an extremely dangerous position, even though the crane operator has been notified to that effect, for there is always the chance of his forgetting or becoming careless.

To provide against accident in such cases the writer has planned a safety device consisting essentially of an automatically operated switch which reverses the direction of the motor when the crane comes within the danger zone.

Very often with large cranes a flat bar or T-rail is used instead of a trolley wire, and in such cases the application

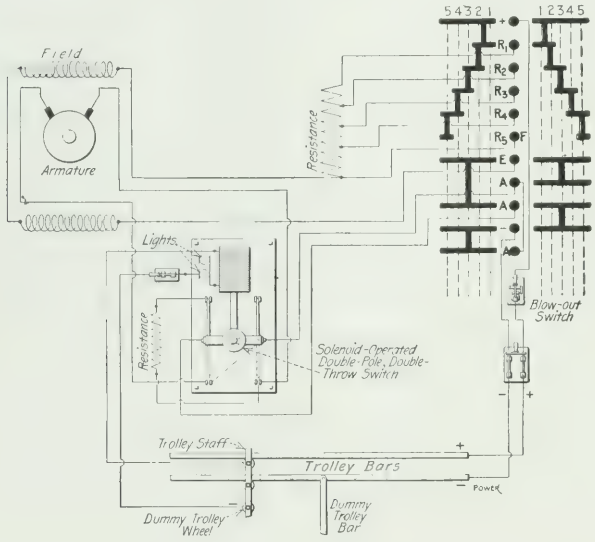


Diagram of Connections

of the safety device is very simple. Holes are drilled in the bottom rail about 15 or 20 ft. apart and through them are hung short bars about 2 ft. long. Ordinarily these are kept up out of the way, but when a man is working on the track he lets down the nearest bar to the place at which he is working.

If the crane is traveling toward him and the operator does not stop it before coming to the auxiliary rail, a dummy trolley wheel carried on the main trolley staff will make contact with the rail. This closes the circuit through a solenoid which throws a double-throw double-pole switch and reverses the polarity of the armature. A diagram of the connections is herewith shown.

A resistance is placed in series with the armature to prevent damage to the latter from the sudden rush of current. A red light is in series with the solenoid so as to indicate to the operator what has happened.

The device has been tried out thoroughly and has given entire satisfaction.

LETTERS

Field Excitation and Load Division of Alternators in Parallel

Will someone please explain why, when two alternators are running in parallel, if one tends to run a little faster than the other the field ammeter on the machine doing the most work does not indicate as much as the one doing less work?

Of course, both machines are running at the same speed when in parallel, but not when disconnected from each other.

V. C. Morris.

Mogollon, N. M.

[Field excitation does not determine the division of load between alternators; that depends on the driving power applied to the respective machines. If the two machines deliver equal voltages at no load when running at equal speeds and with equal excitations, speeding one of them up will necessitate reducing its excitation in order to keep the voltages equal. When the machines are paralleled, the one that has been running the faster will take more load than its mate, because of the governor setting and in spite of the weaker field excitation, but its power factor will be lower than that of the other machine and cross-currents will flow between them. We shall be glad to publish comments from readers of Power.—Editor.]

Automatic Exchange of Excess Loads between Two Systems

In the plant where I am employed there are in regular operation a 600-volt direct-current system for street-railway service and a 2200-volt alternating-current system for lighting and motor service. Sometimes the railway load is heavy while the lighting load is moderate, and at other times the alternating-current load is relatively the heavier. In order to enable one system to help out the other one under either of these conditions, we decided to tie them together electrically. Accordingly, a 200-kw., 550-volt, compound-wound, direct-current generator and a 180-kw., 2200-volt, alternating-current generator of about the same speed were purchased second-hand, both being nearly as good as new. The pulleys were removed and the shafts connected by a flexible coupling. A starting box was connected up for starting the direct-current machine as a motor and the alternator was provided with the usual connections for parallel operation with the main units.

The improvised motor-generator set now floats between the two systems very nicely and automatically. The set is in operation every day and is frequently loaded to the capacity of the alternating-current machine when there is a heavy peak load on the railway system. When the railway load is light it operates as a direct-current motor and an alternating-current generator, taking up to 60 per cent. load, and would take more, but we adjust the rheostat to hold it within this limit, for when it takes much more than this the current passing through the series field winding in the direction opposing the shunt field weakens the total field so much that the machine speeds up until its load throws the circuit-breaker. By adjusting the field rheostat of the direct-current machine several times a day it very seldom throws the breaker.

When this way of operating the set was mentioned to some engineers they would not believe it until they saw it, and one engineer came over 100 miles to see it.

Chas. E. Nigh.

Morgantown, W. Va.

The more nearly steel approaches a pure iron, the longer it resists corrosion. Wrought iron, notwithstanding its slag, is the nearest approach as the slag is mechanically mixed and does not interfere with the chemical properties of the product, says an exchange. Cast-iron pipe, properly casted, is good for a hundred years and under almost any condition of soil.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Overhauling an Ice Plant

By W. S. Luckenbach

The season is at hand for starting up the refrigerating plant. It is essential that the engineer of an ice or refrigerating plant take advantage of every possible economy from the steam boiler to the dump tub, in order to produce the largest possible quantity of ice or refrigeration at the least cost.

Steam Boilers

One of the principal expenditures of an ice plant is for fuel. Hence any improvements that tend to reduce the fuel consumption is money well invested, and if the following adjuncts are not already installed, it would be well to consider them. First, a feed-water heater and purifier of ample capacity is a great help because the water will enter the boiler near the boiling point and foreign matter that would otherwise accumulate in the boiler will be precipitated. It is clear that the less impurities fed into the boiler the less there will be to blow out, and the boiler will steam more easily as the tubes will be comparatively free from scale. While a high-and-low-water alarm is not an actual necessity with a careful fireman, yet by its use the source of bad "butts" may be located. For instance, the water in the boiler may accidentally get too high, the alarm be sounded and perhaps 48 hours afterward defective ice is found. There would be no occasion to search far for the cause. The steam-flue cleaner is another device that is both a labor and fuel saver because the flue doors are not open while the cleaning is being done.

Pumps

The pumps need a careful examination, especially if steam driven. In all cases it will be necessary to determine what will be required to put both ends of the pump in first-class condition while the pump is working under normal conditions. If pumping from a well or stream and using a submerged foot valve, be sure to see that it will give no trouble when every gallon of water is needed in the plant. Do not take any chances and have cause to regret it before the season is over. Rig up a chain block and hoist it out into the clear. If the water valves are rubber and rough on the face, but not cracked, they can be used again by heating a smooth flat disk somewhat larger in diameter than the valves; then grasp the disk in both hands, pass it lightly over the hot disk and occasionally scrape off the burnt rubber on the disk. Continue until a flat surface is obtained. This requires a little practice with a few old valves, but it pays to do it.

Some of the above suggestions apply also to the ammonia pumps. Have as little clearance as possible between the plungers and the heads, also between the top of the valve disks and bonnets in order to avoid the pump becoming gas bound, as this will reduce its capacity because the compressed gas will expand when the plunger recedes and take up space in the cylinder that should be filled with rich liquor. In case, however, the pump should become gas bound, it is a good thing to have a connection between the poor liquor pipe and the pump suction from the absorber, with a valve between. By drawing some of the poor liquor directly into the pump the surplus gas will be absorbed in a few minutes.

Generator

If the generator has been closed for a few seasons it would be a good plan to open it because frequently the coils or tubes become incrustated from impurities in the aqua ammonia and consequently require a higher steam temperature to liberate the gas. The foregoing applies equally well to the dehydrator, exchanger and absorber.

Condensing Coils

If the condensing coils are of the atmospheric type, there will be very little to do, providing a test of the cooling water showed no leaks; with the inclosed double-tube type, however, it may be different by reason of sediment in the water adhering to the pipes. Hence, in order to get full benefit of the cooling water it is essential that they be clean and kept clean. This also applies to the absorber coils or tubes. The pipe conveying the liquid ammonia from the condensing coils to the expansion valve or collector should be run through the coolest part of the building in order to maintain the same temperature if possible as when it left the condensers. For every degree that the liquid is heated in passing from the condenser to the expansion valve it loses about $^1/_{400}$ or 0.25 of 1 per cent. of its effective heat-absorbing power. For this reason it is good practice to place a thermometer in the liquid pipe close to the expansion valve so that the engineer when passing can see at a glance whether he is maintaining the regular temperature on the high-pressure side. Should he find the temperature increasing he will at once know that one of two things must be done: either more cooling water must be supplied or the condenser coils need cleaning, and it will not be necessary to wait until the bath has gone up several points and then hunt all over the plant for the cause.

Freezing Tank and Coils

Suppose that the coils and bottom of the tank have not been cleaned for several years. This work should be done expeditiously because the coils should not be exposed to the atmosphere any longer than is absolutely required. After the tank is emptied, give it a thorough cleaning; be sure and include the can covers and timbers which they rest on to prevent any dirt dropping into the cans when they are filled with distilled water.

In the meantime have the top and bottom manifolds or headers disconnected, clean the flanges nicely and with a little oil on the bolts run the nuts over them. By this time the tank will be clean. Then see that the standards holding the coils are all right and also see that there is no trap in any of the pipes. This is very important. Blow out each coil separately with steam and test with brine, if the weather is cold, to about 300 lb. If a leak should develop, put in a new pipe; do not patch submerged coils unless in the case of an emergency. In case of extreme cold, finish one coil at a time and if there is compressed air, finish by blowing through each coil. The coils should be divided into sections with from two to four coils per section, according to the size of the tank. The section should be connected to a main line or header running the whole length of the bath. By this means a more even distribution of the expanded gas is obtained, and while this is not quite so important in the flooded system, yet it is of equal importance should one or more coils get clogged or spring a leak, because repairs can then be made without much loss, and if there is a valve on the top and the bottom of each coil, the defective coil can be cut out at once.

If the tank is made of steel it should be painted fully as far as the lowest water level, but before painting it must be thoroughly cleaned. As to painting coils, there are various opinions, but one thing is clear; if the coils are not thor-

oughly cleaned of rust the paint will not adhere, and if by oversight a few square inches are painted over rust, all the labor and material are not of much benefit.

The writer has personal knowledge of extra-heavy butt-weld bath coils that were in constant use for 10 years and never had an ounce of paint except the cheap stuff put on at the factory to prevent rusting while in transit. The coils stood a test of 300 lb. with only three leaks. The secret of the lasting qualities is, in the writer's judgment, due to their being submerged continually. In reconnecting, see that the nuts do not jamb into the body of the bolt before the flanges are properly tightened or there may be lots of worry for the man who has to crawl down to replace the bolt with too much body after the machine is started; above all, get the best rubber on the market for that part of the job.

Pipe and Fittings

Use nothing but extra-heavy lap-weld pipe on any part of the high-pressure side of the ammonia system; do not put up a single piece of pipe or nipple without looking through it for blisters. In using a pipe cutter, it frequently happens that it leaves not only a ragged edge but reduces the pipe area; hence every piece should be examined. Do not use old fittings on ammonia piping for two reasons: First, it costs half as much to take them off the pipe and clean them as new ones cost and the threads are never as sharp and smooth as on the new fittings. Do not use any thick pasty substance to make a joint as it will only be a question of time (and a short time at that) when the ammonia will penetrate this paste and a leak result. The writer has personally made thousands of joints and found that by having good threads on both pipe and fitting, using a little flake graphite with good oil and screwing up good and hard, iron to iron, a lasting job will be obtained.

Adjuncts

In addition to those mentioned for the boiler, an automatic poor-liquor regulator attached to the absorber is an excellent investment. It is installed under a guarantee and it does the work. This, in connection with a good ammonia-pump governor, leaves the engineer free to do something besides watch the absorber glass because several pounds variation in pressure either in the generator or absorber will require regulation or chance must be taken of a boil-over or flooding the absorber. On the other hand, if these parts can be relied upon, he will have ample time to devise ways and means of improving the plant that will soon repay the first cost. Another advantage to the engineer is to have a thermometer in the poor-liquor pipe leading from the cooling coils to the absorber, for the same reason that the thermometer would be inserted in the pipe leading to the expansion valve. A thermometer inserted in the feed pipe between the boiler-feed pump and the steam boiler is also a help to the engineer because he can see at a glance whether he is getting the best work out of the heater.

The general appearance of the plant should be made inviting, not only for the employees, but for the employer as well as visitors who may be invited to make a tour of inspection. While it is true that neither paint nor whitewash will make ice, yet a neatly kept engine and boiler room, with tool racks and fitting bins, lends a cheerfulness to the place; it is a credit to the man in charge and is more or less inspiring to all the help in the plant.

Properties of Carbon Dioxide

By F. B. W. Barker

Carbon dioxide (or carbon anhydride), often improperly called carbonic acid or carbonic-acid gas, is composed of one part carbon and two parts oxygen. It is the product of complete combustion of carbon and is always formed when carbon or any carbon compound is burned under conditions that afford an abundant supply of oxygen, and also during decay (slow combustion), fermentation and putrefaction of organic matter.

For refrigeration purposes, carbon dioxide is usually manufactured by decomposing marble dust ($CaCO_3$) with hydrochloric acid. It is also manufactured to some extent as a byproduct in breweries, distilleries and in the calcination of lime and from other sources.

The gas from the retorts or other generating apparatus is confined in a gas tank before its process of liquefaction.

A plant almost identical in its main features with a carbonic anhydride refrigerating plant is used for the manufacture of liquid carbon dioxide. The cylinders or drums in which the carbon dioxide is stored and shipped have a capacity of 800 cu.in. and hold 20 lb. of the liquid.

As a refrigerating medium the value of carbon dioxide is due to its noncorroding action on any of the metals. That it cannot decompose during compression, and that liquid carbon dioxide is cheap, are other points in its favor as a refrigerating agent, as is also its lesser danger to respiration in case of leakage. It is claimed that air containing 8 per cent. of carbon dioxide can be inhaled with impunity, and it is particularly applicable for marine service and confined places on this account. Carbon dioxide is also neutral to meat, water, beer and other products subject to cold storage.

The cubic contents of the compressor may be considerably less as compared with machines using other refrigerating mediums, and the parts must be made stronger on account of the high pressure of the gas. The efficiency of a carbonic anhydride system is somewhat less than that of one using ammonia, due to the small latent heat available for effective refrigeration per pound of liquid circulated through the system. The theoretical coefficient of performance of ammonia is 13.2; that of carbonic anhydride is 11.4; its theoretical performance in a Carnot cycle is 13.6.

A number of practical tests published by Linde a few years ago led him to the compilation of the following table, which shows the excess of efficiency in percentages of the ammonia over and above that of the carbonic anhydride system, both working at different temperatures before the expansion valve, the temperature of the brine surrounding the expansion coil being 23 deg. F. in all cases:

Temperature before expansion valve,

54°, 65°, 72°, 84°, 90°.

Excess of efficiency of ammonia system,

17%, 23%, 31%, 47%, 101%.

As a leak of carbonic anhydride cannot be detected by its smell, considerable quantities can escape before it is noticeable; for this reason special care and supervision are required to prevent leaks in the system when it is in service.

At atmospheric pressure liquid carbonic anhydride has a specific gravity of 1.529 and becomes liquid at a temperature of — 124 deg. F. At 32 deg. it is liquefied at a pressure of 540 lb., and at this temperature its specific weight is 0.93, while at 42 deg. F. it is 0.883; at 47 deg., 0.853; at 65 deg. F., 0.7385, and at 86 deg. F., 0.60 (water equals 1). At 32 deg. F. its latent heat of evaporation is 102.35 B.t.u. per pound of liquid.

From the foregoing it appears that enormous pressure is required to liquefy the gas; this pressure varies in amount in different climates from 750 lb. with water at 50 deg. F., to 1125 lb. with water at 84 deg. F. Another feature worthy of notice, due to the nonpoisonous nature of the gas, is that it is possible to introduce a safety valve, which is a welcome addition to any system employing high pressures.

Once a practicable form of superheater had been evolved, the growth in popularity of the locomotive using superheated steam was inevitable. Had the compound locomotive not made such a bold bid for popularity, superheat would have come into its own many years ago. The latest notable engine of this type is a Pennsylvania Railroad Mallet, with four 27x28-in. cylinders and a boiler pressure of 160 lb.—*Scientific American.*

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
1222 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 74 Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

The Engineering Congress

Preparations for the Panama Pacific Exposition, which is to be held in San Francisco in 1915 to commemorate the completion of the Panama Canal, are now in progress. From present indications, it will mark in a fitting manner the consummation of this great undertaking which the United States will have had the distinction of carrying through.

Aside from the commercial aspect of the canal, it represents one of the greatest engineering feats ever undertaken. For this reason it has been suggested that the several leading engineering societies of this country unite in taking official cognizance of the fact. To this end tentative plans have been formulated for holding a great engineering congress in conjunction with the exposition in September, 1915.

A preliminary meeting of delegates from the American Society of Civil Engineers, the American Society of Mechanical Engineers, the Pacific Coast Gas Association, the American Society for Testing Materials, the Society of Naval Architects and Marine Engineers, the Mining and Metallurgical Society of America, the American Institute of Mining Engineers, the American Institute of Electrical Engineers and the Technical Society of the Pacific Coast was held on Jan. 15 of this year and questions relating to an engineering congress were carefully considered.

As a result, it was decided that the delegates recommend to their respective societies that the annual meeting of each society be held in San Francisco in September, 1915; and that each society represented invite as its guests the corresponding engineering societies abroad. Thus the congress would be made international in scope.

Furthermore, it was planned that, although each society is to proceed independently, there shall be arranged joint meetings at which papers upon kindred subjects shall be read. The exposition authorities have agreed to furnish a suitable auditorium for the purpose and already several of the societies have acted upon the suggestions of their delegates.

The importance of the congress cannot be too strongly emphasized, and all those who have the advancement of engineering at heart should use every effort to make it a success. By having the congress international in character, as suggested, an opportunity will be afforded for clearing up many of the inconsistencies in engineering methods and practice which are now so troublesome when attempting to reduce things to a standard basis for comparison.

One of Many

A correspondent writes us that he "positively knows engineers do not get their dues." In other words, he means that he is not getting as much for his labor as he is worth; that his efforts are not appreciated, and that putting in long hours for small pay is a losing game with some employers.

We know this engineer; he is not a mere starter and stopper, but is the chief of a well known office-building power plant. He buys all supplies for the building, and, although this item is added to the operating and maintenance account, the cost for operating this plant for the past year was one and sixty-eight one-hundredths cents per kilowatt-hour. Not bad!

But his employers are not satisfied with the showing of their engineer, who, in looking after their interests, puts in from twelve to fifteen hours daily at the plant. The men with the manicured finger nails, filled-out vests and slick ways are not satisfied with getting their heat, power and light for a sum far less than the light alone could be purchased from a central station.

And so they want the chief engineer to get along with two assistants instead of three for the twenty-four hours' service, three hundred and sixty-five days in the year. They want the chief engineer

with his executive ability to become a common wiper about the plant, a general repair man and jack-of-all-trades.

And why? Simply because they are greedy; they will not credit to the power plant a sum commensurate with the plant service rendered.

It looks as if the Taylor system was about to be applied; that is, work a man like a machine and expect him to stand the grind equally well.

It cannot be done.

This chief engineer admits that such closeness on the part of the officials of his company makes his position far from satisfactory, and he shows the proper spirit when he says, "It is discouraging work, but so long as I am here, I shall dig in and do more and better work, whenever I can and wherever I can."

This attitude has had much to do with this engineer's success. It will have much to do with his future. While his present employer may be willing to lose an efficient chief engineer and save the wage of one assistant, there are those who are looking for this chief engineer to operate their plant, but do not know where to find him. More, they are willing to employ enough men to obtain effective supervision and would not permit a chief to do an oiler's work.

We predict that this engineer will, ere long, be called to fill a better and more responsible position.

Power Station Records

Power-station records are a necessity if it is desired either to obtain the unit cost of the power or to study plant economies. In manufacturing plants, power is an item of operating expense and hence a positive factor in the final cost of the manufactured product. In plants furnishing heat, light and power, the unit cost becomes the basis of the selling price. This knowledge while not as important in the operation of small isolated plants as in connection with central power stations, is even here essential to an analysis of the costs. Many a plant is operated, however, with no attempt to differentiate the cost of running the power department, dependence being placed upon the ledger balance to determine whether the establishment as a whole is profitable. If this is the case, but little further attention is usually paid to the power costs.

This information is valuable when the question of continuing the operation of the small plant or taking current from the central station is under consideration. The management is justified in changing to central-station power, other things being equal, if it may be obtained continuously at a cheaper rate than the manufacturing cost of the power in the small isolated plant. If this cost is not definitely known, there is no way of telling which arrangement is actually the cheaper.

The importance of this information is quite generally understood by efficient plant managers, but it is not always easy to obtain it. The principle is very simple. The cost of the coal, supplies, labor and the fixed charges for a definite period divided by the total power output for the same period will give a value for the unit cost. This involves the making and keeping of various records in the power plant.

If the load is entirely electrical, the value of the total work output may readily be obtained either by reading the integrating wattmeter or by averages obtained from consecutive readings of the ammeters and voltmeters. If the output is not entirely electrical, the procedure is usually more complicated. In each case, however, it will be possible to take such measurements and keep such records as will enable one to ascertain the total work output.

The operating expenses are made up of the cost of the coal or other fuel, water, supplies, repairs, labor, office expense and the fixed charges, which items must be determined separately and added together to make the total for a given period.

The duration of the period is a matter of some importance. It must neither be too short nor too long; a month would seem to be about right. This is short enough for but slight climatic changes and long enough to get a fairly representative result.

The plant test is another method of obtaining the unit cost. In addition to yielding the desired information concerning the cost of power, a large amount of information in connection with plant economies would be obtained in this manner. This method involves a special arrangement of apparatus and the making and recording of a considerable number of observations. The principle is necessarily the same as that previously explained. The total work output for a limited period, usually short (twelve to twenty-four hours), and the total operating expenses for the same period must be obtained. This means that the coal and water consumption must be accurately measured for the duration of the period. A number of such representative tests taken within a comparatively short interval may be averaged to obtain the final result.

The records made in connection with the ordinary operation of the plant are largely a matter of judgment and personal convenience. The problem is what records are useful in each particular instance, rather than how many. The instruments of measurement available are automatic coal weighers, water meters, steam-flow meters, carbon-dioxide meters, smoke recorders, thermometers, pyrometers, tachometers, calorimeters, etc. All of these records are not necessary in any one plant or even desirable unless the plant is operated on the basis of a continual test.

The making and keeping of power-station records is one thing and the interpretation of them is another, as the record itself has no virtue unless it is used and profit made of it; it must be studied and interpreted and the conclusions arrived at must be carefully and thoughtfully applied.

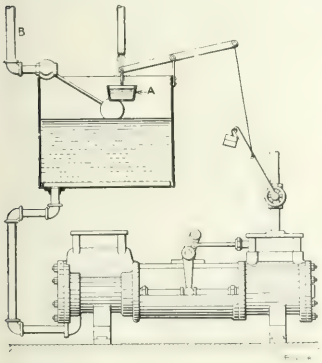
In our attempt to ward off from Arthur C. Davis, of the engineering department of the Equitable Building, the storm of criticism which was being directed against him for having, as it was asserted, neglected to send in an alarm and trying to extinguish the fire with his own force, we did the gentleman an unintentional wrong by questioning how the chief engineer of a plant like that of the Equitable happened to be on hand at that untimely hour unless he had an intimation of trouble. It develops that Mr. Davis is not the chief, as all the papers were calling him, but the night engineer. He was on duty, as he should have been, and did an engineer's duty under exceptionally trying circumstances to prevent the bursting of boilers from adding to the horror of the catastrophe. We regret that even by implication we should have called his conduct into question.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Automatic Pump Regulator

The accompanying figure shows an arrangement which I have devised to automatically keep the storage tank on the roof full. The small pail *A* controls the steam valve of the pump. The overflow from the tank empties into the pail, causing the valve to close. A small hole



AUTOMATIC PUMP CONTROL SCHEME

in the bottom of the pail allows the water to drain out. When no overflow is falling into the pail the water drains out and the weight on the valve lever over-balances the weight of the pail, opens the valve and starts the pump.

The makeup water is automatically supplied by the pipe *B*, which is controlled by a float valve, as shown.

E. T. LEHMAN.

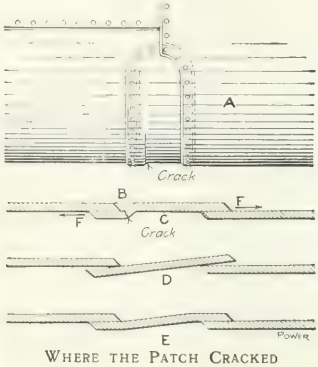
Chicago, Ill.

Patch Cracked

One of our boilers had a patch on the bottom, extending about half way of the circumference, as shown at *A*. This was an offset patch, as shown at *B* and—evidently due to the mud settling in the V-shaped hollow, as indicated at *B*—got overheated at that point probably many times before the plate cracked.

All of a sudden one of the firemen noticed steam issuing from the boiler setting, and by the time the fire was pulled, the ashes in the back end of the boiler were soaked to a paste. A light was fastened to the end of a long stick and held under the boiler, when it was discovered that a stream of water was issuing from the shell of the boiler. When the boiler was cooled down sufficiently for a man to get inside the brickwork, it was found that the patch was cracked, in the offset, as indicated at *C*.

This patch was ripped off and a new one cut and rolled to the required radius, but not offset, as shown at *D*. After scarfing the patch it was bolted to the boiler, four holes having been drilled for that purpose. A gasoline burner was



WHERE THE PATCH CRACKED

used to heat the edges. After it was fitted, holes were scribed to match the holes in the boiler; the patch was then removed, the holes drilled and it was then riveted in place, as shown at *E*.

Making a straight patch obviates the hinge feature in its offset part. The expansion tends to straighten the plate, as indicated by the arrows at *F*. The point where the crack developed is also shown in this view.

Using the straight patch lessens the tendency of mud to settle on account of a more gradual slope to the plate.

V. T. KROPIDLODLOWSKI.

Winona, Minn.

Improved Turbine Steam Valve Spindle

A great fault with the nozzle valves of the electric-control type of steam turbine is that the pistons will work loose from the valve spindles.

The brass nut which fastens the piston to the spindle will either unscrew and drop the spindle through the piston, thereby closing the valve or, in the case of the latter pattern of pistons and spindles, where keys and keyways are provided to prevent this trouble, the threads of the nut and often of the spindle will strip, resulting either in costly repairs or putting a valve out of commission when it may be badly needed.

This defect can be prevented by remodeling the spindle *A*, shown herewith, and making a new part *B* to which the valve disk is to be secured. The piston is then put on the spindle in the usual manner; afterward, drilling and riveting it as at *DD*. The spindle can then be put in place in the valve-chest bonnet, and the part *B* screwed on, drilled and riveted as at *E*.

WILFRED E. BERTRAND.

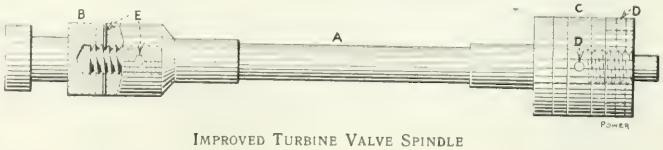
Philadelphia, Penn.

Pumping Engine Speed Limit Device

A horizontal cross-compound Corliss type of pumping engine pumping to a reservoir against a practically constant head had a speed-changing device applied to the governor to regulate the supply to suit the demand. The governor controlled the cutoff for the high-pressure cylinder while the cutoff for the low-pressure cylinder was regulated by hand.

This arrangement worked all right within certain limits, but when the demand was light and the engine was run at low speeds the governor would often take to surging, and on one occasion the belt ran off and the safety cams failed to work. Of course, the engine started to race—and so did the engineer.

This engine was equipped with a well known type of stop which closes the throttle when the speed reaches a predetermined point. In this instance, the engine stop operated, sounding an alarm; but it was then discovered that it was possible to tighten the packing on the throttle-valve stems to such an extent as



IMPROVED TURBINE VALVE SPINDLE

to make this form of engine stop almost inoperative.

The increase in load due to speeding up the pump was sufficient to keep the

speed from reaching a dangerous point before the throttle could be closed enough to control the engine.

Steadier and more satisfactory operation was afterward had by putting a positive, hand-adjusted cutoff arrangement on the high-pressure valve gear, discarding the governor altogether, and keeping the engine stop in good operating condition to act as a speed limit.

WILLIAM E. FRANCIS.

Lynn, Mass.

Troublesome Heating System Pump

In 1906 I took charge of a plant which included a 60-in. by 16-ft. return-tubular boiler and a 5¼ and 3½ by 6-in. piston-packed duplex steam pump. The manager assured me that the plant was to be considered as the last word in factory construction, steam heating, etc., but I viewed the future with misgivings after I had wrestled with the steam-heating end of it for a week.

The architect had very carefully designed a hole about 6x7x4 ft. deep, and down in that hole the receiver and pump had been placed. The pump was set against one side of the pit wall and in order to pack the pump it was necessary to recline on one side, wedged between the pump and the wall.

No valves were placed in any of the return pipes discharging into the receiver, so that, when the plunger packing gave out, the new packing had to be put in while the contents of the factory return pipes poured over the hands of the unfortunate victim. In addition to this, the bucket traps on the kilns gave a double-barrelled discharge of more hot water about once every three minutes.

Next, the brass lining on the water end of one side tore loose from its moorings, and trotted up and down with the plunger until it brought up against the covers, blanking the port and staving up the end of lining.

The antics of that pump would make our friend "Potblyn's" pump look like a Sunday-school superintendent. Of course, a new bushing had to be procured and when it arrived I discovered that it was a full ½ in. too small. I called up the pump makers and was informed that they depended on the beading of the ends to hold the bushing in place. The manager, who was aware of all the facts in the case, began to hint that he preferred the word of the pump makers to mine, and I saw that the best thing for me to do would be to rely on my own resources, and prove the makers wrong.

I took a piece of galvanized iron and bent it around the outside of the bushing, applied white lead to it and pulled both snugly into place with a long threaded bolt, after which I beaded it over. All this was done while deluged with hot water.

The brass suction and discharge valves, four of which were on each deck, were made so thin that after a couple of months' use they dished up all round, bearing only at the center.

I made a pattern and got eight new bronze valves of the same size as the original ones, but reinforced with little webs, radiating from the center, so that bending would be impossible in the future.

The next thing to receive attention was the steam valves. One side of the pump always cushioned very nicely but the other side traveled until the spool struck the stuffing-boxes. I found one of the valves longer than the other and a difference of ⅛ in. in the thickness of the valve nuts which in this case were pieces of iron about 2 in. long and 1⅛ in. wide. One was ½ in., the other ⅝ in. thick. I made the valve short enough to just reach from the extreme edge of the admission port at one end to the extreme end at the other.

Right here, I made a radical departure from accepted practice in pump construction. I made the new nuts thick enough to just fill the slot in the back of the slide valves, so that there was none of that famous "lost motion" except what the wear in the valve motion supplies.

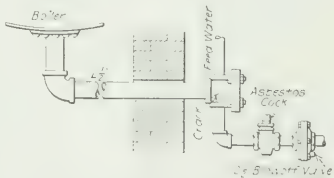
Brass bushings in the links, the removal of the receiver out of the hole altogether, placing the pump on a neat concrete bed, made in the middle of the pit and a foot higher than formerly, were changes I made after the first winter, and "Potblyn" himself would be satisfied with the smooth running of our old pump, now that the causes that bewitched her are removed.

GEORGE HILTON.

Hamilton, Ont., Can.

Fitting Fractured

While working on a job last fall, an incident occurred in a plant which contained four return-tubular boilers, the



FRACTURED FITTING

safety valves of which were set to blow at 100 lb. pressure. These boilers were connected in the rear to a cross connection. An asbestos-packed blowoff cock next to the boiler was always left open. Connected to this was a second blowoff valve.

On looking for the cause of a small leak, I found the blowoff cross cracked as shown in the accompanying sketch. The boiler carried 100 lb. of steam.

I believe that the fireman in blowing down the boiler closed the blowoff valve too suddenly and caused a water-hammer which cracked the fitting.

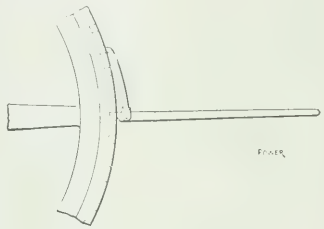
HUGH MCDONALD.

Oak Park, Ill.

Starting Bar

Having had considerable trouble with engine-bars slipping and wearing the slots out of shape, I made the bar shown in the sketch, and it has proved very effective.

It can be used on any engine or compressor if the flywheel is provided with



STARTING BAR IN POSITION

slots; it will not slip, for the harder the pull, the tighter it grips. It fills a long-felt want in our plant.

The handle may be made short and fitted with a suitable piece of pipe if preferred.

H. H. DELBERT.

Titusville, Penn.

A Reducing Valve Repair

A reducing valve on a pipe line supplying steam to an engine at 100 lb. pressure gave trouble. In the same plant there were a number of small steam engines, heaters, etc., supplied from two boilers working at 60 lb. pressure. The idea of the reducing valve was to relieve the other two boilers, should there be a heavy demand for steam. The valve consisted of a valve and piston controlled by a small valve which could be adjusted to blow off at any desired pressure.

The valve had been in place for some time, but was not working. This was rather troublesome as there might be a light load on the engine during the day, and a heavy demand for steam from the other two boilers. The piston of the main valve was grooved for a ring, but the ring had been removed. The result was that the main valve would not lift, should the small valve open and admit steam, as the steam passed the piston without moving it.

I was told that with the ring in place the valve would open all right, but that it would open too far and refuse to close, thus causing a sudden rush of steam in-

to the other pipes, resulting in the other boilers blowing off, and the steam supply taken from the engine.

I decided that this action of the valve was due to lack of drainage of the space under the piston—the space would fill with water—and that when the small valve opened the steam would lift the piston all right but the space would then fill with condensed water. When the small valve closed there would be practically no escape for the water; this would account for the valve remaining open.

Acting on this idea, I had a new ring made, and, instead of fitting the ends as closely as possible, I left them a short distance apart so that any water could readily escape; this also kept the piston from rising too quickly. This seemed to have been the matter, as the valve gave no further trouble; it opened and closed gently at any desired pressure.

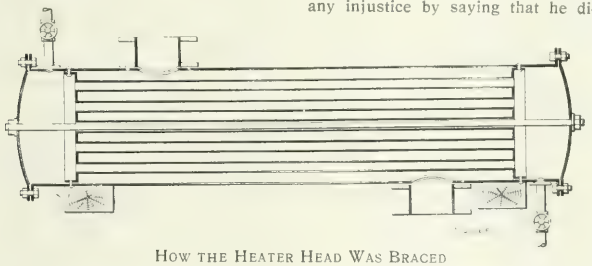
W. BURNS.

Govan, Scotland.

Braced Heater Heads

Some time ago I was employed at a small boiler shop where a home-made heater was used. The joints on the heads could not be kept tight with different kinds of gaskets, although the faces were forced off true.

I decided that the head was springing, as it was made of ⅜-in. boiler plate and was about 30 in. in diameter. The heads were bumped slightly. I put a stay-bolt through the center tube with a lead washer under each nut on the heads. This cured the trouble. The heater was used with a feed-water pressure of about 125 lb. per square inch.



HOW THE HEATER HEAD WAS BRACED

LEO GRANDMONTAGNE.

Youngstown, Ohio.

Relation between Employer and Engineer

For the employer there is this to be said, he has the many cares and responsibilities that go with any business on his mind all of the time and he may be excused if he forgets for a time his employees and their troubles. On the other hand, to get business success he must depend largely upon his employees, and the shrewd manager realizes this.

In the case of the central-station companies the power house and the man in charge are all important, but in many other organizations, while the power plant is a necessary part, it does not always receive proper consideration.

There are among engineers, as there are among other classes of workmen, those to whom it would be impossible for any employer to make any advances of a nature favorable to the employee which would not be viewed with suspicion, for they would be so fearful of there being "a string to it" that the favor would be unappreciated. For these there is not much hope of making their relations with their employers any more pleasant.

There is a large number of men, however, who wish to do the right thing and with such as these it will pay the employers to keep in closer touch not only by simply using them well and not bothering them, but also by showing them that some interest is being taken in their work.

I know of an instance where a small central-station company had a very difficult power plant to operate, and even though it was new, for the first year and a half there were frequent shutdowns and accidents. Having hired a new engineer who took great interest in the business from the start, things began to look brighter for the company.

Now, I do not wish to do the manager any injustice by saying that he did not appreciate the improved condition of things, for undoubtedly he did; not, however, because it was better for the company but because it relieved him of some personal responsibility.

When the ambitious engineer had the plant running on a good operating basis he rarely ever saw the manager at the plant and if he went to the office he found that his employer seemed to be ready to discuss almost anything else. Even when, after an increase of business, the load became so great as to make it a question whether the machinery would pull it, the manager showed no alarm nor would he bring himself to look into the matter with the engineer, thus making the employee feel that he was wasting his energy when the man higher up did not seem interested. He felt the lack of that support which would have strengthened his interest and kept him contented with his position.

This man had proved by several years' good work that he was the right man for the place and any far-seeing manager would have discovered that fact. Instead, the manager in this case forced the engineer to resign in disgust because of the indifference which he displayed.

How often one hears of a position as engineer of which it is said: "The job pays well, but they are hard people to work for." This may not mean that they are continually hounding their engineers, but that they hold them at such a distance that there is no bond of sympathy and that when something serious does happen, the employee is given no chance to explain and either leaves or is discharged.

Relationship is a great factor in making faithful employees and when it is properly followed it makes up for years of system and rules in maintaining efficiency. In all cases it is first necessary to get a good man and then, to get good work from him, to use him well.

G. H. KIMBALL.

East Dedham, Mass.

See the Hump

The hump which appears in the expansion line of the accompanying diagrams seems to be due to the indicator itself. I took seven sets of diagrams, five with one indicator and two with another. Of the first five sets, four showed the hump and one did not. Neither of the two sets taken by the second indicator showed the hump.

DIAGRAM HAVING HUMP IN EXPANSION LINE

What is your explanation?

PHIL LIGHTE.

Woodhaven, N. Y.

Graphite for Hot Bearing

A few days ago I paid a visit to my friend Sam who runs a large pumping station.

I noticed as I entered that there seemed to be quite a bit of excitement going on and all hands were congregated about the crankshaft of one of the 40,000,000-gal. engines.

The usual paraphernalia most in evidence where there is a hot bearing were lying around accompanied by a 1¼-in. water hose. The hose was being applied with indifferent success.

A crackling, sizzling sound came from the bearing, which was steaming profuse-

ly, and no amount of water seemed to have any effect; the shaft and quarter boxes were cold. But the face of the drag-crank was about the hottest thing I ever saw.

Sam said the engine had been on for about two hours before it started to heat up. He had tried to cool it off by dumping buckets of fresh oil into the handhole, but this only made it smoke worse. They use a light, cheap oil and a gravity-oiling system, the oil costing about $75 per 1000 hp. per month, which does not speak well for his choice of oil. He tried to get grease to the bearing but could not, so he applied his trusty hose.

Sam has great faith in water, but he would lose it mighty quick if he were driving generators instead of pumps.

After he had shut down and taken the cap off and the top shell out, we found that the face of the crank had worn tightly against the frame and the oil could not get to it.

We tried to push it over by setting the quarter boxes in, but the crankpin held it. We could not slide the bottom shell out, as the flywheel was too close. To raise the crankshaft and chip oil grooves in the bottom shell would mean a two days' job and the unit could not be spared that long. So Sam chipped oil grooves in the cap and top shell and put them and the other stuff on again and started up.

Ten minutes later he had the hose going again and the steam and oil were sizzling as merrily as ever.

"Sam," I said, "suppose you take the hose out—it isn't doing any good—and pour graphite and cylinder oil down that hole."

Sam came back with a snort, saying that if that was all I knew it would be better for me to get back to the power house and my toy engines. "Graphite," he said, "was good stuff to put on water gaskets and to make pipe dope of, but for hot bearings, cold bearings or anything that moved, it was nix."

He had read an advertisement which said graphite was "grand" for bearings and he said he was foolish enough to try some on a little 20-hp. vertical engine used for driving a circulating pump, whereupon the box got so hot that if he had not used the hose it would have been a case of pouring a box, or perhaps a broken crankshaft. Out in the boiler house, under the vise bench, I found an old teapot about half full of the kind of graphite used in foundries, which had about as much grit in it as graphite.

I had just bought a 5-lb. tin of graphite, so I went over to the power plant and brought it back, finally persuading Sam to let me try it on his bearing.

It was Hobson's choice with him as he had shut down again. He turned the engine over slowly while I poured the graphite into the oil groove that had been cut in the top shell and cap, pouring about a teaspoonful of graphite and a little cylinder oil for about every 10 revolutions. We kept this up for about half an hour and then speeded the engine up to about 25 r.p.m.; its full speed is 35½ r.p.m.

I continued putting a little graphite and a lot of cylinder oil down the groove for an hour longer and left half a can with him. At that time the bearing was pretty hot, but it seemed to stay at the same temperature, and so I took that as a sign that it would cool off in an hour or so.

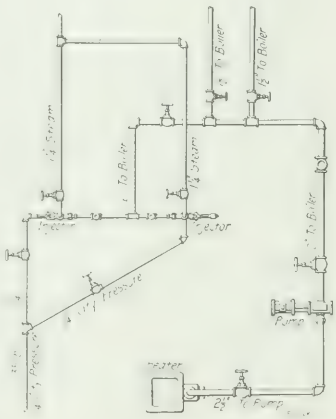
I visited Sam the next day and found the box about 110 deg. F., and there were two cans of good graphite in the supply cupboard.

CHARLES BENNETT.

Chicago, Ill.

Will the Injector Work?

The accompanying illustration shows the arrangement of two injectors and a boiler-feed pump. I would like to know



INJECTOR CONNECTIONS

if both injectors will work at the same time in case the boiler-feed pump failed. One injector will not supply both boilers.

J. L. BROUSE.

Elyria, Ohio.

Grinding Hard Rubber Valves

When truing up hard-rubber pump valves with emery cloth the surface soon glosses over.

My present arrangement for truing them up is to use two pieces of broken grindstone about 10x8x2½ in. in size, in which two of the flat surfaces were made perfectly true by abrasion, wetting and rubbing them together until each piece has a perfectly clean, true surface.

When about to grind the valves, wet both pieces and bring the true surfaces together and rub slightly to make each surface sharp and clean and deposit fine sand on the surface. Then rub the hard valve over the stones until a true surface has been obtained. As soon as the floating sand has been used or the pores seem to close with the grinding substance of the valve, rub the stones together again to clean them.

GEORGE B. MICHAEL.

Dayton, Ohio.

Temperatures in Engine and Boiler Rooms

I have observed at this time of year that great losses occur in engine and boiler rooms that ought to be avoided. It is surprisingly common to see engine and boiler rooms with windows and doors open on days when the temperature is anywhere from 30 deg. down to zero weather, sometimes with a cold wind blowing right through on the cylinders of the large engines and on the walls of the boiler settings.

Where the practice exists, it is because the men in charge have never thought of making a simple calculation of the effect of temperatures on the radiation of heat. In one plant of which I had charge I made a practice of going around and closing the windows and doors on cold days for two or three days, soon finding that in a short time someone would raise them again.

Finally, one day as an assistant was raising the window near the cylinders of a tandem-compound engine, through which the cold air would blow on the lagging of the cylinders, I asked him if he did not realize that all the air thus admitted to the engine and boiler rooms was being raised in temperature at least 30 deg. I then told him to make a calculation with me to determine what this radiation of heat meant. I explained that the amount of heat radiated depended mainly on the difference in temperature of the heated body and the surrounding air.

After going over the matter with him, it was not necessary to advise care in this particular again; he was much surprised at the result of our calculations.

I then explained to all the men that the only object in ventilating an engine and a boiler room was to keep them at a comfortable temperature, and that in summer to favor the bearings when necessary it is desirable to keep the engine room as cool as possible. In winter there is no fear for the bearings; the rooms should be kept well warmed to avoid excessive condensation in pipes and cylinders, and in the boiler room to avoid radiation of heat as much as possible from the boilers and settings.

Of course, insulation assists in this very much, but it is not claimed that the most careful insulation prevents this loss. The amount of these losses, however, will vary according to the temperature differences between the air in the room and the heated body.

WILLIAM WESTERFIELD.

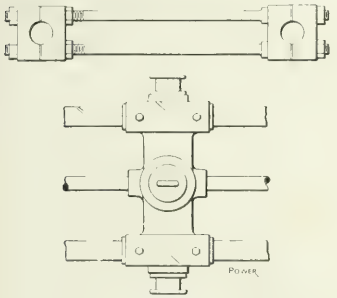
Lincoln, Neb.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Knocking in Air Compressor

In reply to Frank Richards' criticism in the Jan. 30 issue, I would say that the knock referred to does not occur near midstroke but when the cranks are passing the centers. This is due entirely to the wear and take-up of the side rods. The accompanying figure shows a construction in which the builders provided threaded rods so that they may be adjusted. When this style of machine



DETAIL OF CROSSHEAD AND CONNECTING RODS

gets out of true much friction is caused. I have seen a balance-wheel key worked loose by this trouble.

Mr. Richards is mistaken when he says that a machine can be run with much variation in the length of the side rods.

C. R. McGAHEY.

Baltimore, Md.

Engine Load Not Equalized

The unequal load trouble described in the Jan. 23 issue is due to the late cutoff in the low-pressure cylinder. The cutoff in this cylinder should be shortened; this will raise the receiver pressure and put more work on the low-pressure side.

From the appearance of the low-pressure diagram it would seem as though this were an engine running noncondensing which was designed to run condensing. To take the loop out of the low-pressure diagram it will be necessary to do one of the following things: attach a condenser, increase the load on the engine, reduce the steam pressure, or reduce the number of revolutions.

J. K. McINTYRE.

Newburgh, N. Y.

If Mr. Gordon will shorten the cutoff on the low-pressure cylinder the load on this cylinder will increase and become less on the high-pressure cylinder. This change of load comes from the shorter cutoff giving a higher receiver pressure, and thus more back pressure in the high-pressure cylinder; less power is then developed in the high and more in the low.

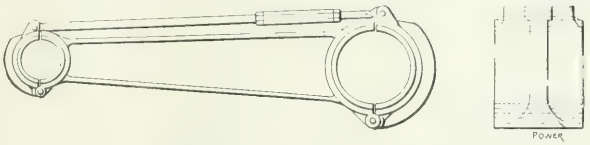
JOHN WALLACE.

Syracuse, N. Y.

Connecting Rod Ends

J. A. Levy's article on "Connecting Rod Ends," in the issue of Jan. 30, is of considerable interest. Though perhaps outside the scope he intended, it would have been interesting to have noted the different types of gas-engine rods as well. There is one make of connecting-rod for such work that I have never seen illustrated outside the maker's catalog. The sketch herewith shows the principle of the rod very well.

The outer parts of the rod ends are hinged below and pulled together at the top with a sleeve nut shown on top. The piston end is brass lined while the large crank end is babbitt lined. With the rod properly designed the pressures at the ends are always in correct relation so that when one end is adjusted for proper running the other is also. This is a great advantage, particularly in gas-engine work, where the boxing in the piston is very hard to get at for adjusting.



CONNECTING ROD WITH HINGED ENDS

In assembling the engine it was the custom to slip the rod into the piston, force in the pin and then the piston and rod were erected in the engine. The large end opened wide enough to slip over the crankpin readily. In this respect it has no advantage over the rod with a solid end in the piston, but it is superior in respect to its ready adjustment.

M. W. PULLEN.

Boston, Mass.

In regard to J. A. Levy's article pertaining to connecting-rod ends, in the Jan. 30 issue, I would say that from his statement in the last paragraph we are to believe that one type is as good as another; that it is only a matter of individual taste as to which type is selected.

Admitting that each type shown represents a great number in use giving entire (?) satisfaction to the users, it does not necessarily mean that all are alike, as there are many engineers, owners, etc., using machinery who have come in contact with one style only; they do not know whether anything else is better.

Referring to Figs. 5 and 6 of his article, Mr. Levy says these are mostly used on center-crank engines. This is because they are employed extensively by steamship-engine builders, and are therefore termed "marine ends."

I know of one company which employs this type on all of its engines—traction, portable and stationary. One great advantage of this type is that by taking out the proper number of shims the brasses can be brought together so rigidly that they are "locked," as it were, and yet, the bore is just "an easy fit" on the pin, whereas with other types, if this "locking" were attempted, the pin would be clamped until it would be impossible for the engine to operate.

With the marine end there is never a question of new brasses; only a small quantity of good babbitt is needed occasionally, and enough common sense with which to apply it.

LLOYD V. BEETS.

Nashville, Tenn.

Another Dynamiting Case

I was much interested in the letter, "Dynamite for Removing Pinion from Shaft" which appeared in the Jan. 30 issue, because of an experience I once had with dynamite.

Our problem was to remove two wheels

from a car axle from which we wished to turn a shaft for an electric mine locomotive. The first wheel was heated and then forced off with two screw jacks placed between the two wheels, but the other gave us trouble. After some discussion dynamite was resorted to in the following manner:

A short stump of tree sawed square at both ends, about 18 in. in diameter and 2 ft. long, was placed on end in an out-of-the-way place. The axle was placed on this and also stood on end. As the axle extended beyond the wheels about 8 in. to form bearings, there was room enough to shoot the wheel downward and off. Two sticks of dynamite were placed on the wheel, one on either side of the shaft, the shot was fired, and the wheel came off; but the shaft broke at the upper end, even with the shoulder formed by turning down for the bearing. However, the shaft was long enough for our purpose as the axle was from a car of a standard-gage road and the locomotive was for a narrow-gage mine road.

M. A. HANSEN.

Richfield, Utah.

Wanted: Engineer of Pleasant Disposition

I believe Mr. Morton is altogether wrong in his definition of "pleasant-disposition engineers." For the life of me I cannot see that an engineer with a pleasant disposition need necessarily be backboneless, brainless, a coward, a knownothing, etc., as suggested by Mr. Morton.

An engineer's greatest asset is a disposition to be calm and pleasant under trying or adverse circumstances. Subordinates have no respect for a surly superior, although they may fear his usually unjust and caustic remarks.

JOHN THORN.

Toronto, Ont.

License Laws of Massachusetts and Ohio Contrasted

The interesting article by Joseph King in the Jan. 23 issue on "Examiners and License Laws" is one of the many recently published which take a fling at the Massachusetts license law and its examining force.

In Ohio we have a law and an examining force, and the contrast between the two laws shows everything in favor of the Massachusetts statute. In the latter state the provisions of the law are carried out in spirit as well as in letter, and the examinations, as a general thing, are thorough and to the point, sifting and weeding out the incompetents. The oral form of examination gives the examiner an opportunity to size up the applicant, and with the aid of the large-size models a very thorough and practical examination can be made.

On the other hand, the license law of Ohio is not as efficacious. The form of examination is the coveted written one which so many of the men in Massachusetts would like to have. With this form, however, the examining force does not have a chance to estimate the man's personality and mental make-up as thoroughly as they would with the oral form. Another point against this form of examination is the fact that an applicant can be "loaded," as the examination questions are printed and not changed for each new set of applicants.

Some day the people of Ohio are going to wake up and send a carload of men down to Massachusetts to see how business is transacted there, and how the laws are enforced.

I will say that the wage condition in our state is somewhat improved since our law was passed.

ORRIN C. WERNER.

Kent, Ohio.

The Management's View

The foreword in POWER of Jan. 23 is one of the truest things ever published. It is a regrettable fact that a large percentage of employers fail to see just why a man in charge of a power plant, even only a small one, should be possessed of any special knowledge of power-plant apparatus, to secure economical results. This ignorance seems to be almost universal, and it is not confined exclusively to employers; there are numerous engineers (?) in every community who enjoy the same misbelief.

Within sight of the plant where I am employed is a small factory where I worked over 10 years ago. I installed a new boiler and small Corliss engine there, and as soon as everything was operating nicely, I was informed by the management that, since things were running so smoothly, it was not worth so much to run the plant and that a cut from $2.25 a day to $2 would be made; that it was not business to pay the engineer much more than the superintendent—he got $1.75 per day.

I stepped out. A man took my place who was a so called engineer while I was still in the country school, and he accepted $1.75 per day.

Just previous to his retirement a few months ago, this engineer bragged that during the time he had run the plant he had never seen the valves of the engine or the inside of the cylinder and had never applied the indicator to the engine; neither had he been inside of the boiler, either to examine it or to wash it thoroughly.

He cut out the exhaust-heating system which I installed and not only used live steam (which was never put in for service only when there was no exhaust steam), but let the returns run to the sewer.

His successor is a young man full of enthusiasm, and with a good knowledge of his business. After examining the plant carefully he got into the boiler and found that near the back head the scale had filled in solid between the tubes. The engine cylinder had to be rebored and a new piston head put in. The valves were worn down fully ⅛ in. The ports were also rebored and new valves furnished.

The plant now uses more than a ton of coal per day less than formerly, and the management now sees that my successor would have been dear had he worked for nothing. Yet the management had been satisfied because it did not know any better and fully believed that as the plant was comparatively small, no skill was required to operate it. It should have hired an engineer when it wanted an engineer!

GEORGE H. WALLACE.

Racine, Wis.

Water Softeners

In the Jan. 9 issue, Mr. Hawkins inquires about water softeners. There are certain features and requirements which should be filled by every water-softening and purifying process. Briefly, these are as follows:

(1) The water should be examined and analyzed by a competent person to insure its accurate chemical treatment. (2) The final result must be perfect clarification. (3) The chemical reagents must be thoroughly and efficiently mixed with the water. (4) The chemical reactions must be complete. (5) They must also be as rapid as possible. (6) The sedimentation brought about by the action of the softening plant must also be rapid.

Any water which contains over 2 pints of total solid matter per 10,000 pints or over 1.75 pints of calcium or magnesium sulphate or carbonate, should, of course, be treated by some method of purification.

There are two methods of water purification, one in which the necessary amount of chemical ingredients is added to the water in one or more large, intermittently used tanks, one feeding while the water in the other is being treated. The other method is that in which the mixing is automatically accomplished.

Constant and intelligent supervision is essential to the successful application of either method, however. The operator should make sure, by daily tests, that the plant is working satisfactorily and sufficient time is allowed for the proper performance of the chemical reactions or else there will be much waste.

There are three undesirable kinds of impurities in boiler-feed water which cause scaling, corrosion and oil deposits. Scaling may be partly avoided by preheating the feed water, but the substances

producing the hardest scale, namely magnesium and calcium sulphates and carbonates, require chemical treatment for their removal.

The treatment of water containing corrosives usually involves the use of caustic soda, the effect of which is to neutralize the acid content of the water and to leave it slightly alkaline. Gaseous impurities causing corrosion—usually either chlorine, carbon dioxide or oxygen—may be got rid of by heating the feed water up to about 200 deg. F.

Filtration is the only satisfactory method of dealing with oily impurities. If the oil is emulsified with the water to such an extent that filtration alone will not separate them, it is advisable to use this method as a preliminary to the after treatment. The latter may undertake the removal of the oil by coagulation and precipitation or by electrical treatment. The general run of oil-separating devices is, however, rather unreliable and the effluent therefrom should be tested for purity every day.

In order of importance, the foregoing classes of impurities should read: oil, corrosives, scalers. The first two are dangerous, while scale only reduces the efficiency and not the life of the boiler.

JOHN S. LEESE.

Manchester, England.

Sand for Hot Boxes

The articles appearing in POWER under this heading have led to considerable verbal discussion in England, and for the most part the suggestion of using sand for hot boxes appears to be a huge joke. However, during my experience of many years as a seagoing engineer, I have myself adopted the sand treatment, as a last resort in difficult cases, with complete success

British marine engineers do not include sand in their list of stores, but for scouring bright work they use a mixture of sand and silt, found in the bed of a tidal river in Somersetshire, known as bathbrick.

Many years ago, when I was a junior engineer on the Warren Line steamers, sailing between Boston, Mass., and Liverpool, we had on one voyage considerable trouble with a main bearing, 14 in. in diameter, which persisted in running hot in spite of all attempts to keep it cool. We had tried all the time-worn methods of slacking back the cap and drenching the bearing alternately with graphite, white lead and sulphur, mixed with oil in each case, and even the ship doctor's available supply of castor oil was poured in, but without success. All this was done under the supervision of the second engineer, who naturally thought himself able to overcome a hot bearing without the chief's assistance.

Apparently, the chief suspected something wrong—he probably smelt it—for he came down into the engine room to find the writer holding a hose over the bearing while three other engineers stood by and told one another in poetic language what they thought about it.

When informed that the bearing simply would not run cool, he told one of the juniors to scrape a handful of bathbrick into a pint of oil and pour it into the bearing through the handhole in the cap. Although we had the greatest respect for our chief's ability as an engineer, it seemed to us that he had suddenly developed a kink in his brain, but we were there to carry out his orders and we did as we were told, the second engineer in the meantime standing by the throttle, ready to slow down when the sand got a grip on the journal and began to pull up the engines.

The mixture of sand and oil was poured into the bearing slowly, being stirred constantly to prevent the sand from settling, and when it was all in, the bearing was allowed to run for about a minute; then about half a gallon of kerosene was run through to wash it out thoroughly, and finally the bearing was well oiled in the usual manner. The whole performance did not cover five minutes, after which the chief left us without waiting for results. The bearing did not trouble us any more, and when it was opened in port everything was clean, unscored and in perfect order. Many years afterward, as chief of a Mediterranean trader, I plucked up courage to try the same cure on an obstreperous main bearing 9½ in. in diameter, with equal success.

Now for the other side of the picture. Shortly after, I met in Genoa an old shipmate who was chief of another steamer, and in the course of conversation the subject of hot bearings was broached and I spoke of my experience with the sand remedy. Like most people, he was skeptical, and said so, but when I explained my theory he recovered sufficiently to admit that there might be something in it. We were sailing next day, both bound for Odessa, and, of course, we made a small bet on who would get there first. We lost sight of one another soon after sailing, and when my ship arrived at Odessa I was mildly pleased to find that my friend had not arrived.

His ship turned up two days later, and as soon as she was made fast he came to me with blood in his eye. He had applied the sand remedy to a hot bearing exactly as I had prescribed, and as a consequence was obliged to put into Constantinople to take out the bearings and file and scrape them into working order before they could proceed. He flatly accused me of playing a low-down trick on him in order to win the bet, which he declared to be off on a foul.

I went aboard his ship and had a look at the bearing, which bore undoubted signs of ill treatment, and as I puzzled over the problem, the truth came to me. In each case where I had used sand the bearings were of gunmetal, but in this instance the bearings were lined with white metal, so that when the sand had been put in it had become embedded in the soft metal and stayed there to scratch the journal.

It is obvious, then, that while sand can be applied with success in some cases, in others it would ruin a bearing under similar conditions.

The term "sand" suggests a hard, gritty abrasive, and this probably accounts for the derision with which the idea has been received in some quarters, but there are plenty of fine sands, similar to that to which I have referred, which, when mixed with oil or water, are easily ground to a soft mud under pressure between two metallic surfaces.

I quite agree with the theory that the cooling is due to the roughened surfaces allowing the oil to have access to the wearing parts in a manner that would be impossible with smooth or highly polished surfaces, but I also go farther and suggest that the effect is chiefly due to the fact that the sand rubs down the high spots that are the primary cause of the trouble. The amount rubbed off, however small, is sufficient to ease the load and distribute it among the other bearing points in the same line.

Whether either of these theories is right or wrong has yet to be proved, but the fact remains that sand is good for cooling hot bearings—provided one has the right kind of sand and a suitable bearing.

S. JONES.

London, Eng.

Why Not Glass for Hot Boxes?

When I read the first account of using sand in a hot bearing, I thought the writer must have lots of sand to publish the fact. I believe in the adage, "Where there is smoke there must be fire," and after reading more articles I became less skeptical; at the present time I would like to see it tried out.

As I understand the matter, it is a question of being able to get rid of all the sand after the operation. Very finely ground glass is now used for grinding in gas-engine valves. This has superseded emery because it does not tend to bed itself into the metal like the latter. If this is the case, why would it not be a good substitute for the grit we have read so much about people using which varied all the way from gravel to brick-dust?

I would like to hear from anyone who tries this method out.

JOHN BAILEY.

Milwaukee, Wis.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Center of Gravity

Where is the center of gravity of a trapezoid 50 in. long at the base, 6 in. high at one end and 4 in. high at the other?

G. G.

Referring to the illustration, the line *L* joining the middles of the altitudes is a line of gravity and is divided in such a ratio by the center of gravity that the following construction for finding the latter holds good. Prolong each altitude in opposite directions an amount equal

CENTER OF GRAVITY OF A TRAPEZOID

to the other altitude; join the two points thus found; the intersection with the other line of gravity is the center of gravity.

Another rule to obtain the center of gravity is:

Measure along the line of gravity from the higher altitude a distance equal to one-third the length of the base multiplied by the sum of the high altitude and two times the low altitude and divided by the sum of the high and the low altitudes.

Substituting figures for the rule, it would be expressed thus:

$$\frac{50}{3} \times \frac{6 + (2 \times 4)}{6 + 4} = \frac{50}{3} \times \frac{14}{10} = \frac{70}{3} = 23\tfrac{1}{3} \text{ in.}$$

Refrigerating Capacity of an Ammonia Compressor

What is the refrigerating capacity of a double-acting 12⅛x25¼-in. ammonia compressor, speed 60 r.p.m., in tons per 24 hours, if the back pressure is 30 lb., the head pressure 150 lb., the average temperature of the cooling water, 86 deg. F. and the temperature to be maintained in the brine tank is 17 deg. F.?

K. J. E.

To determine the refrigerating capacity of an ammonia compressor, divide the product of its cubic capacity and its volumetric efficiency by the number of cubic feet of gas per minute required at the temperature and pressure of expansion, and the temperature and pressure of liquefaction of the gas.

The capacity in cubic feet per minute of this compressor may be determined by multiplying the area of the cylinder by twice the length of stroke and by the number of revolutions per minute, and the product divided by 1728. Substituting figures for the rule, it would be expressed as follows:

$$\frac{(12.6875)^2 \times 0.7854 \times 25.25 \times 2 \times 60}{1728} = 186 \text{ cu.ft.}$$

To produce one ton of refrigeration per 24 hours at 150 lb. head pressure with cooling water at 86 deg. F. and 30 lb. back pressure and 17 deg. F. temperature of expansion, 2.615 cu.ft. of gas pumped per minute would be required of the compressor. For other pressures and temperatures more or less gas would be required, according to circumstances. This can be found in a table showing the refrigerating effect of ammonia at different pressures and temperatures, in any of the better class of engineers' handbooks. Assuming the volumetric efficiency of the compressor to be 80 per cent.

$$\frac{0.80 \times 186}{2.615} = 56.8 \text{ tons}$$

per 24 hours would be the capacity of the compressor.

Elevation of Boiling Point

Can the temperature of the boiling point of water at a given pressure be raised?

G. P.

Substances held in solution by water will raise its boiling point. A saturated solution of salt will boil at 214 deg. F.; and a saturated solution of calcium chloride at 370 deg. at atmospheric pressure. The boiling point of pure water free from gases may be as high as 260 deg. F.

Heat Units per Ampere

How much heat is developed in a wire per ampere of current?

R. W. O.

The heat units developed per second are proportional to the watts passed through the wire. The rise in temperature is proportional to the watts divided by the effective radiating surface. One watt is equal to 1.35625 ft.-lb. per second, and 778 heat units equal 1 ft.-lb.; therefore

$1.35625 \times 778 = 1055.1625$ *heat units* per second will be developed when one watt or one ampere at a pressure of one volt will be applied to the circuit.

Size of Generator for an Engine

What size generator could be operated by a 50-hp. engine, and how many 16-cp. lights would the generator supply?

C. L. R.

Assuming the overall efficiency of the engine and dynamo to be 85 per cent., this engine would produce at the dynamo terminals

$$50 \times 0.85 = 42.5 \text{ hp.}$$

One electrical horsepower equals 746 watts; therefore this engine would be capable of driving a generator producing

$$42.5 \times 746 = 31{,}705 \text{ watts}$$

or 31.7 kw. The nearest standard size generator would be 30 kw., or 30,000 watts. A 16-cp. carbon-filament lamp requires 56 watts, and a tungsten-filament lamp requires 20 watts. The generator would furnish current for

$$\frac{30{,}000}{56} = 530 \text{ carbon-filament lamps}$$

or

$$\frac{30{,}000}{20} = 1500 \text{ tungsten-filament lamps}$$

Heat Values

What are the relative heat values of gasoline, kerosene and ordinary illuminating gas as used in internal-combustion engines?

S. E. M.

Ordinary commercial gasoline contains about 18,000 B.t.u. per pound. Petroleum of a specific gravity of 0.87, has 18,000 B.t.u. per pound. Kerosene of a specific gravity of 0.8 has a value of 19,000 to 20,000 B.t.u. per pound. The heat value of illuminating gas varies greatly with the character of the gas, ranging from 500 to 700 heat units per cubic foot.

Absolute Zero

What is the temperature of absolute zero, and how is it determined?

G. A. Q.

The expansion of a perfect gas under constant pressure is about $\frac{1}{492}$ of its volume at 32 deg. F. If the gas were cooled down to 492 deg. below freezing, or 460 deg. below zero, its volume would in all probability become zero. Various values are given by different authorities. That adopted by Marks and Davis in their steam tables as representing the greatest degree of accuracy attained is 459.64.

Annual Dinner of New York Steam Boiler Inspectors

The American Institute of Steam Boiler Inspectors of New York City held its second annual dinner at the Broadway Central Hotel, on Wednesday evening, Feb. 21, President T. T. Parker presiding.

Among the guests was Joseph H. McNeill, chief inspector of boilers for Massachusetts, who, by special permission of Governor Eugene N. Foss, addressed the guests on "The Advancement and General Adoption of the Massachusetts Boiler Laws in the United States and the Philippine Islands."

Mr. McNeill told of a new book which the department will shortly issue giving the details of all the ordinary sorts of riveted joints. He said that the usual attempts were being made to amend the law. One of these, that requiring all boilers to be inspected by the state whether insured or not, the department was opposing, but it was urging an amendment authorizing a state inspector to shut down any boiler which he found in a dangerous condition regardless of insurance. Mr. McNeill related an instance where a boiler was found running with the safety valve removed and the opening plugged.

Brief speeches were made by other guests and members of the institute, and letters of regret were read from Col. Meier, of the Heine Boiler Co., Inspector-General George Uhler, of the government steamboat service, and Chief Inspector Wirmel, of Ohio.

An election was held resulting in the choice of the following officers for the ensuing year: President, J. M. Winter; vice-president, J. G. Shaw; secretary, R. A. Thomson, Travelers Insurance Co., 1 Madison Ave.; treasurer, James White; executive committee, Charles H. McAleenan, chairman; F. C. Williams, J. G. Gillespie, L. A. Turnbull, A. J. Lappan.

Retiring President Parker was presented a handsome gold watch.

New York Boiler Inspectors at Annual Banquet

New Orleans Convention of American Boiler Manufacturers' Association

A round-trip rate of $56.30 has been established from New York to New Orleans for the twenty-fourth annual convention of the American Boiler Manufacturers' Association and the Supplymen's Association at New Orleans, Mar. 12 to 15.

This rate entitles the holder to stop off at all the principal points along the line, and is good going and returning, until May 31, 1912. The Southern Ry. Co. is offering through-train service between New York and New Orleans, solid Pullman trains with drawing-room, compartment, sleeping, dining and observation cars.

It is advisable to secure Pullman accommodations at once. Also advise F. B. Slocum, secretary, Supplymen's Association, West and Calyer Sts., Brooklyn, N. Y., as to the time of arrival in New Orleans.

Fiftieth Birthday of Lunkenheimer Co.

The Lunkenheimer Co., of Cincinnati, Ohio, in honor of its fiftieth anniversary, tendered its employees and families an elaborate entertainment and dance, Saturday evening, Feb. 17, at the Armory, and over 4000 people attended. Provision was made for the entertainment of the employees' children, who were present in large numbers, and refreshments were served in great abundance.

Some conception of the growth of the Lunkenheimer Co. in less than a life time may be had when consideration is given the fact that in 1862, when the late Frederick Lunkenheimer laid its foundation, it had a small, one-man shop. He created a demand for his products that soon necessitated larger shops and more men, and this increase has continued until today the company occupies factories covering acres of ground and in which are employed 1500 men.

Swedish Engineers Honor Ericsson's Memory

The American Society of Swedish Engineers celebrated, on Feb. 17, at its home, 271 Hicks St., Brooklyn, N. Y., in connection with its annual dinner, the fiftieth anniversary of the "Monitor" and "Merrimac" battle, and paid tribute to the memory of Capt. John Ericsson, the inventor of the "Monitor."

Among the speakers were the Swedish consul, Magnus Clarholm; Erik Oberg, associate editor of *Machinery*, and W. Apel Warn, of the New York *Times*.

Civil Service Examinations

United States civil-service examinations will be held on Mar. 13 for a junior mechanical engineer for the Bureau of Mines, and on Apr. 10 for a cadet engineer in the lighthouse service, an engineer in the inland service and a junior engineer—mechanical or electrical—in the engineering department at large. Application forms and full information may be obtained by addressing the United States Civil Service Commission, Washington, D. C.

OBITUARY

Louis Delaunay-Belleville, the celebrated French engineer, died at Cannes, France, on Feb. 10. He was well known as the inventor and manufacturer of the Belleville boiler. Born in 1843, M. Delaunay-Belleville studied at the Ecole Polytechnique and the Ecole Navale, and in 1867 entered the Belleville engineering works. The works had established a reputation for the excellence of their boilers, but Delaunay-Belleville, by his talent and energy, gave an added impetus to the business and rose rapidly to be head of the firm. He enjoyed wide respect and esteem in commercial and engineering fields, and was an associate member of the British Institution of Naval Architects.

PERSONAL

G. J. Wells and A. J. Wallis-Tayler have formed a partnership under the title Wells & Tayler, as consulting engineers at 78 Fleet St., London, England. Mr. Wells has held positions on the staffs of the British Westinghouse Co. and other well known firms. Mr. Tayler has for some years had charge of extensive sugar estates and mines abroad and has also had considerable experience in refrigeration and cold storage. He is known in this country through his works on refrigeration.

Moments with the Ad. Editor

You remember that in the issues of January 23 and February 6 we asked these questions:

1. Which ad in this week's Selling Section of POWER, describing a product you have not been previously interested in and so far as you know have no present need for, gives you the strongest impulse to investigate it immediately? Why?

2. Which ad in this week's Selling Section seems to you to have the biggest "storing-up" value—as described above? Why?

3. Which ad seems to you THE BEST, in every way? Why?

4. Does any ad seem to you open to improvement? If so, how?

5. Which ads did you answer?

The answers have been surprisingly good and unusually interesting.

It is gratifying to note the interest manifested by POWER subscribers in the subject of advertising and particularly POWER advertising.

Like most questions on subjects which are not mathematically scientific, they provoke widely different opinions.

They are individual opinions, yet, taken as a whole, there is a consensus of opinion favoring certain kinds of advertisements which well informed advertising men know are the most productive.

In all questions pertaining to the worth of certain ads the critic is led in his selection by the *product* in which he is most interested. It influences his decision somewhat.

Question four, which asks for expressions as to which ads are open for improvement brought out some good *constructive* criticism. These opinions will be forwarded to the advertisers, but will not be printed here for the very good reason that it would be obviously unfair to the advertisers. They are *manufacturers* and do not pose as advertising *experts*.

Those letters which seem to be the best fitted to teach a lesson to readers or advertisers will be published from week to week. The ad editor may have something to say about each letter—a little friendly talk from *his* point of view.

In many cases the writers have asked that their names be withheld and this will be done in every case.

Number one is from the chief engineer of a large concern in Winsted, Conn., and just because he says we "dassent," we will let it see the light of printers' ink—and see it first.

In your editorial of Jan. 23, you ask for our opinion on several very delicate questions, some of which require the engineer to be a diplomat in the art of telling a man that his child is all right, but— Now, you see, we are dealing with the most of these good fellows, as well as you who have a mission to fulfill with an object which is honorable and ambitious on your part. The advertising business undoubtedly lies very close to your heart. Therefore I make a guess that none of our views ever see daylight in printers' ink, but for what good my individual opinion will be, you are welcome to it.

In looking over the ads of this week, I find one from the American District Steam Co., of North Tonawanda, N. Y., advising investigation into the problem of using surplus exhaust steam for heating neighboring buildings. I am not in a position at present, or do I know when the time will be opportune for such a proposition, but I know that my environments are ideal, and all data on the subject will some day be of great value, so they got an inquiry from me on this subject.

The ad that in my opinion has the biggest educative value is the Simplex Seatless Blow-Off Valves of Yarnall-Waring Co., of Philadelphia, Penn., on page 77, notwithstanding that the Nelson Valve Company has a full page ad on the same subject, and practically the same article; but the question is, why was my attention called to the Simplex with half the space? My opinion is that it was the cut of the valve taking up most of the space, and being very explicit in detail. Then it may be because the Nelson ad came afterward that my interest and inquiry were obtained in this instance, but the Nelson Valve Co. will, later on, receive a letter from the firm asking for information on the subject.

The ad that I consider par excellence, is the American Steam Gauge and Valve Mfg. Co., of Boston, Mass., on pages 54 and 55 of Jan. 23, 1912, issue.

Its prominence in position and space, its make up of bold face type treating intelligently and concisely each subject they wish to bring before the reader are good. The initiative place in the department of business is a factor, for the saying that there is a place for everything and everything in its place holds good, especially in advertising. It is my opinion that such matter placed in the first pages or on the covers of any publication receives secondary consideration from those regularly classified.

This ad as I open the doors of business, strikes me like meeting one of the firm in the engine room with hand extended, with the cheerful greeting of, "Well, my boy, how is this old world using you?" Although I have to say in the end that there is nothing in his line that I am in need of at present.

The ads I answered this week are: Schaeffer & Budenberg, and Schuchardt & Schutte, tachometers; the American District Steam Co., bulletin; Yarnall-Waring Co., valves.

There you are, chief. Your letter is in printers' ink and it deserves to be because you've put the matter well.

Next week one or more additional letters will be published and these show other angles of the question.

POWER

Vol. 35 NEW YORK, MARCH 12, 1912 No. 11

We have some thirty thousand subscribers scattered all over the country. It ought to be impossible for anything of general interest in the power-plant line to happen without our getting quick knowledge of it. No such thing could happen if any large proportion of our readers would consider themselves a part of the POWER family and if each, when anything happened in his neighborhood that seemed to be of more than local interest, would drop us a line, or telegraph at our expense if the importance of the event warrants.

What a power we could be if we had a lookout in every town!

We do not expect such service for nothing. We try to make any effort exerted for us worth while.

Don't let anything stop you. Be the first to send the news.

It is not to us that the service is rendered. It is through us to the power-plant owners and engineers of the country. They pay us and we pay those who help.

We do not expect finished articles. We want the news, facts, ideas. If every time a boiler explodes, or a flywheel bursts, somebody would even telegraph us that it had happened we could follow up the clue and assemble here statistics of such casualties that would be extremely valuable for use in argûments for remedial legislation.

We could draw from such of them as offered the material, engineering lessons upon the design, construction and operation of such apparatus that would help avert further catastrophes.

We should like to know of new power plants and of important extensions to existing installations.

We should like to know of changes in position by prominent engineers, of important papers presented to engineers' societies, of new things proposed for power-plant use, whether these promise to be of real value or are of the too frequent fallacious or fraudulent variety.

Won't you take this to yourself, and the next time you learn of anything that you think POWER readers would be interested in, send it to us. You will be doing the engineers a service, and we will see that your trouble is not lost.

Hazard M'f'g Co.'s New Power Plant

By Warren O. Rogers

An ideal station supplanting several steam engines scattered throughout the factory.

Individual motor drive will be used on the wire rope making machinery.

Originally, the Hazard Manufacturing Co., Wilkes-Barre, Penn., following the practice of the day, had its several steam engines used in the manufacture of wire rope, insulated wire and cables, etc., located at convenient points in the factory and adjacent to the machines which they were to drive.

Some of these engines are in use at the present time, but their days are numbered and they will soon be displaced by electric motors, which will obtain electrical energy from the generators in the new power plant that has recently been constructed; much of the machinery in the factory has already been changed to motor drive.

The engine room is 40 ft. wide, 92 ft. long and 30 ft. high from the floor to the trusswork which supports the roof, which is sheathed with 2½-in. planking and covered with asphalt and gravel. The room is made exceptionally light by the large amount of window area. The floor is made of 2½-in. flooring and this is covered by 1-in. hard maple, upon which strips of Scotch linoleum are laid where the greatest wear takes place.

Engines and Generators

At present there are two 22x36-in., four-valve, double-eccentric Corliss engines installed, each of 328 amperes capacity, and run at 120 r.p.m. Each engine is connected to a 250-kw. alternating-current generator, which delivers electrical energy to the switchboard at 440 volts. This voltage permits of operating the motors in the factory without the use of transformers. Where lights are installed using a lower voltage, the transformers are placed in a fireproof vault built in that part of the factory in which the motor is located. All wires are placed in iron-pipe conduits, and all switches and fuses are confined in an asbestos-lined wood or metallic box.

Both generators are run in parallel without difficulty. Each engine is equipped with a special flywheel 16 ft. in diameter, the extra weight in the flywheel assisting in the regulation. Fig. 1 shows a view of the engine room.

Auxiliaries

The other machinery in the engine room consists of a belt-driven 125-volt exciter generator and an induction motor driving a direct-current 250-volt generator. The latter unit is used for supplying direct current to the factory for elevator and crane service.

Switchboard

The switchboard is placed at one end of the engine room and is made up of seven marble panels, two of which are for the generator control, three dis-

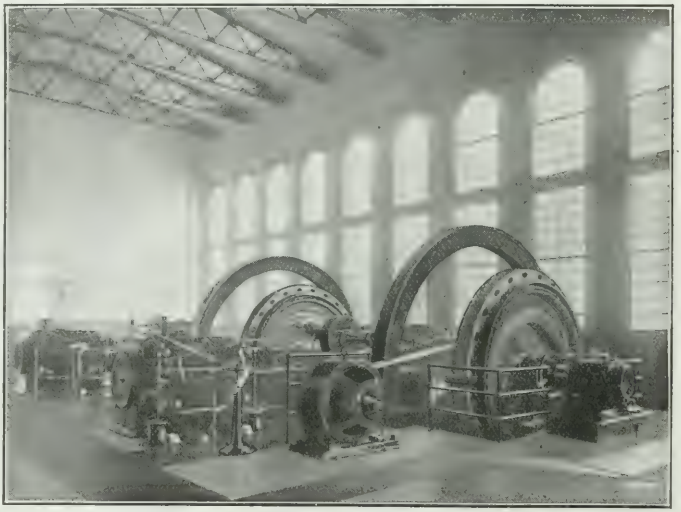


Fig. 1. New Engine Room of the Hazard Manufacturing Co.

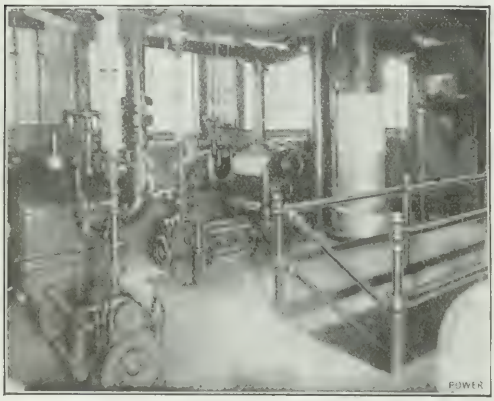


Fig. 2. Vacuum Pumps on Heating System

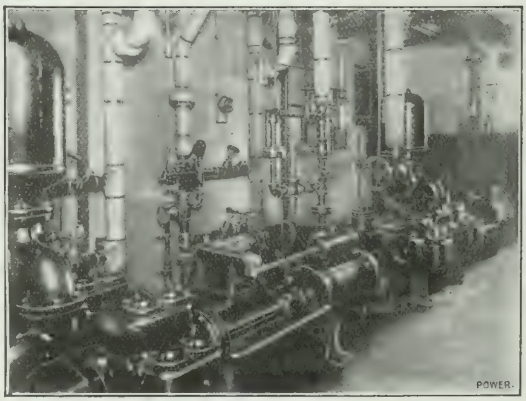


Fig. 3. Boiler-feed Pumps

tributing panels and two instrument panels. Double busbars have been provided so that in case the motor load causes fluctuations in the lighting circuit the motor and lighting circuits could be handled separately from the two busbars. Under present conditions, however, both services are taken from the same busbar. The power factor ranges between 80 and 85. There is floor space for an additional unit of double the capacity of either of the single engines.

Boilers

In the boiler room, Fig. 4, there are four 308-hp. water-tube boilers. They are set with two boilers in a battery, and a steam pressure of 100 lb. per square inch is carried. No. 2 buckwheat coal is burned with the aid of forced draft, which varies from ½ to 1 in., according to the thickness and condition of the fires. The forced-draft fan is located in the pump room beside the brick stack. The air is forced through the ashpit of each boiler and through a 44-in. galvanized-iron air duct, which tapers from an end section 75 in. in diameter at the fan connection. The fan is 10 ft. in diameter, 5 ft. wide and is driven by a small steam engine that is automatically controlled by a damper regulator, which operates a butterfly throttle valve. The gases of combustion pass from the combustion chamber of the boilers to a brick smoke flue constructed under the rear end of the boilers. This smoke flue is 9 ft. wide and 7 ft. 6 in. high, with the roof curved at a 9-ft. radius.

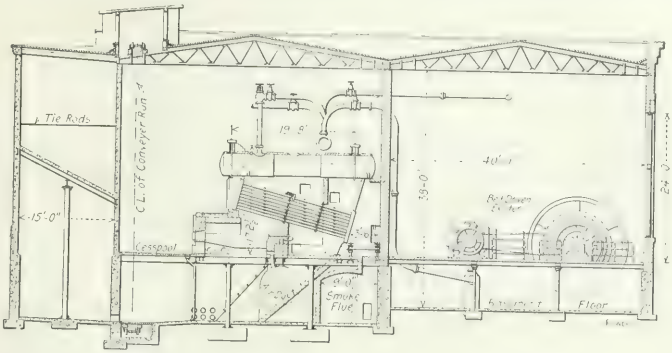


Fig. 5. Elevation of Coal Bins, Boiler and Engine Rooms

The smoke connection between the combustion chamber of each boiler is 2 ft. 6 in. wide and 10 ft. long. The smoke flue extends along the back of and under the boiler to a brick stack which is 125 ft. high and 10 ft. and 13 ft. inside and outside diameter respectively at the bottom, and 8 ft. and 9 ft. 2 in. inside and outside diameter respectively at the top.

Aside from the forced draft, each boiler is fitted with a steam blower and a shaking and dumping grate, each furnace having 10x10-ft. grate surface. The blowers are not used while the air fan is in operation, but are an auxiliary feature in case the fan arrangement becomes deranged. The boilers are equipped with dutch-oven furnaces and hand firing is used. Exhaust steam from the fan engine is passed to the ashpit of the boilers to assist in preventing the formation of clinkers.

The boiler furnaces are designed to burn the finer sizes of anthracite coal. Another feature is that the clean-out doors in the side walls are hinged at the top so that in case of gas explosion the doors will be blown out at the bottom and, swinging on the hinge, damage to the boiler fittings is avoided.

The mud drum of each boiler is fitted with two 3-in. blowoff pipes which connect with the main 8-in. blowoff pipe. This permits the steam to expand before it passes to the sewer. A trap is formed between the sewer and the boilers by a drop leg, cross-section and a riser pipe, the latter discharging to the sewer.

Coal is delivered to the coal bins by a bucket conveyor and the ashes are handled by the same conveyor. The fuel is dumped on the firing floor from the coal bins after it has passed through a coal weigher.

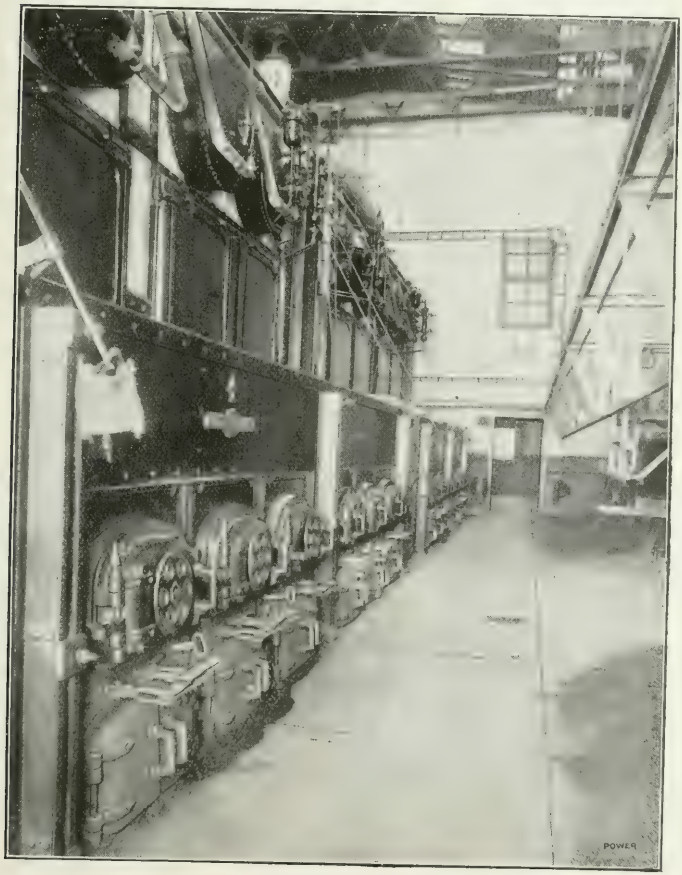


Fig. 4. New Boiler Room, Showing Dutch Oven Construction

Pumps

Two 10 and 7 by 18-in. outside-packed pumps supply feed water to the boilers, taking the water from an open heater at a temperature of between 210 and 212 deg. F. The boiler-feed pumps, shown in Fig. 3 are made with a long stroke, thus avoiding frequent reversal in the piston travel.

Exhaust steam is used in the factory-heating systems, but when exhaust steam is not available, such as holidays and Sundays, live steam is reduced from boiler pressure to between 25 and 30 lb., after which the steam passes through a second reducing valve and goes to the factory at a pressure of ½ lb. per square inch. The returns are taken care of by two vacuum pumps, shown in Fig. 2.

Piping

In Fig. 5 is shown an elevation of the boiler and engine rooms and illustrates the design of some of the more important pipe lines. Fig. 6 is a plan view. Each boiler is connected to an 18-in. steam header by an 8-in. steam pipe. The connection between the header and each engine is made with an 8-in. pipe which extends just through the wall between the boiler and the engine rooms and then drops to the basement; then it runs across to the engines. The steam passes through a separator which is placed in the engine-room basement.

The exhaust pipes from each engine are each 10 in. in diameter and connect with a 20-in. exhaust main.

The exhaust steam passes to a feed-water heater and either escapes to the atmosphere in warm weather or is exhausted to the heating system during cold weather. All steam piping is fitted with steel flanges tested to 250 lb. pressure per square inch.

The boiler-feed pipes are fitted with Y-valves when possible and are made of brass.

Several interesting features of this plant will be treated in a separate article which will be published in an early issue.

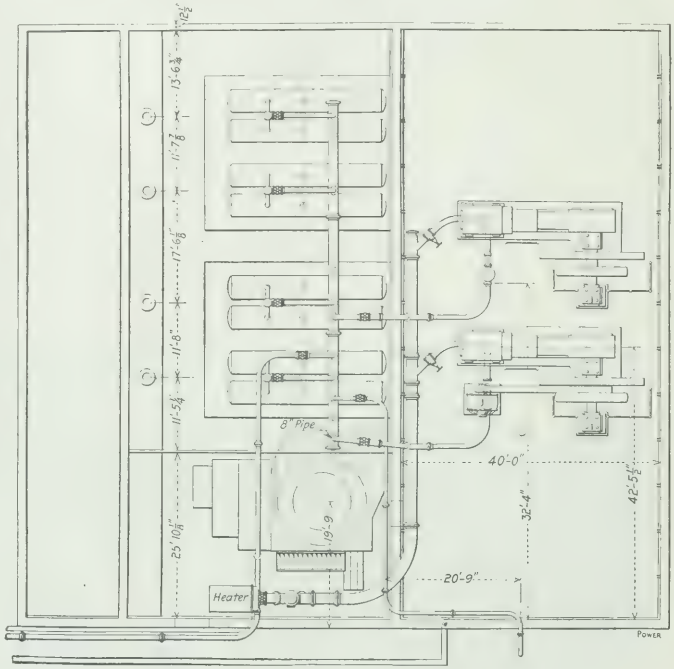


FIG. 6. PLAN OF BOILER AND ENGINE ROOMS

EQUIPMENT OF POWER PLANT OF HAZARD MFG. CO.

No.	Equipment	Make	Use	Rated Capacity in Kw.	Horsepower	Steam Pressure, Pounds	Revolutions per Minute	Volts	Amperes	Phase	Cycles	Size	Manufacturers
4	Boilers	Water tube	Main steam generator		300	100							Babcock & Wilcox Co.
2	Engines	Rice & Sergeant	Main generator units	250		100	120					22x36	Providence Engineering Works
2	A.-C. generators	Westinghouse	Main generator units	250			120	440	328	3	60		Westinghouse Elec. & Mfg. Co.
1	D.-C. generator	Crocker-Wheeler	Auxiliary generator	45			690	250	180				Crocker-Wheeler Co.
1	D.-C. generator	Westinghouse	Exciter unit	224			450	125	180				Westinghouse Elec. & Mfg. Co.
1	Induction motor	Westinghouse	Auxiliary generator		60		690	440		3	60		Westinghouse Elec. & Mfg. Co.
1	Induction motor	Westinghouse	Coal conveyor motor		10			440		3	60		Westinghouse Elec. & Mfg. Co.
1	Switchboard	Marble	Mch. and line control										Westinghouse Elec. & Mfg. Co.
												5' wide	
1	Fan	Sturtevant	Forced draft									10' dia.	B. F. Sturtevant Blower Co.
1	Damper	Spencer	Damp. and fan control										Thompson, Richards & Co.
1	Chimney	Custodis										125' high	Alphons Custodis Chimney Construction Co.
4	Water columns	Reliance	Safety water column										The Reliance Gauge Column Co.
4	Regulators	Vigilant	Feed water regulators										The Chaplin-Fulton Mfg. Co.
4	Blowers	Argand	Steam jet blower										McClave-Brooks Co.
4	Grates	McClave	Furnace shak. grates										McClave-Brooks Co.
1	Separator	Sweet	Steam separator										Direct Separator Co.
												10x7x18	
2	Pumps	Duplex	Boiler feeders										Nelson-Snyder Mfg. Co.
2	Pumps	Vacuum	Heating system										Nelson-Snyder Mfg. Co.
1	Injector	Hancock	Boiler feeder										Hancock Inspirator Co.
4	Regulators	Mason	Pump regulators										Mason Regulator Co.
1	Open heater	Cochrane	Feed water heater		1800								Harrison Safety Boiler Works
1	Heating system	Webster	Factory heating										Warren Webster & Co.
2	Lubricators	Richardson	Force feed										Richardson Phenix Co.
1	Filter	White Star	Oil filter										Pittsburg Valve, Foundry & Construction Co.
1	Conveyor	McCaslin	Coal and ash										Meade Morrison Mfg. Co.
	Piping	Extra heavy	Steam and water										W. K. Mitchell
	Fittings	Crane	Pipe lines										Crane Co.
	Valves, large	Chapman	Steam mains										Chapman Valve Mfg. Co
	Valves, small	Hancock	Steam and water										Hancock Inspirator Co.

Forces of Expansion and Contraction

By Edward Ingham

Showing force exerted by freezing water within a closed vessel, also that due to the expansion and contraction of a boiler shell when subjected to a considerable change in temperature.

How these factors are provided for in design.

Readers of Tyndall's "Heat: a Mode of Motion," will remember how vividly he pictures the practically irresistible forces which are set up when the atoms which go to make up the material universe are exposed to the action of heat or cold. For example, a sphere of cast iron, only 2 or 3 inches in diameter, with walls as much as ½ inch thick, when filled with water and hermetically sealed, and then placed in a freezing mixture, is violently ruptured in a short time by the all-powerful atomic forces brought into play when the water expands during the process of freezing.

When the iron vessel is placed in the cooling mixture, the water, as it first begins to cool, contracts in bulk. The contraction continues until the point of maximum density, 39 degrees Fahrenheit, or 4 degrees Centigrade, is reached, after which the water commences to expand, and later changes from the liquid to the solid form.

At this point, a small vacuous space exists within the sphere, due, of course, to the contraction of the liquid, and as the expansion and the change from the liquid to the solid form proceed, this vacuous space gradually becomes filled. To accomplish the change, however, more room is required, and this the rigid iron refuses to grant. But its rigidity is powerless in the presence of the atomic forces of expansion, and the iron shell is violently ruptured.

A very simple calculation of the pent-up steam pressure which would be required to burst this iron vessel will give some idea of the tremendous force which has been exercised by the molecules of an ounce or two of water in merely changing its state. In fact, the pressure required would be well over 10,000 pounds per square inch.

The writer recalls an instance where a steam boiler over 7 feet in diameter had been filled over night with water for a hydraulic test on the following morning. The boiler was situated in the yard of the boiler works, and during the night a severe frost set in. As a result, when the boilermakers came to apply the water pressure the following morning, they discovered that the water in the boiler had been converted into a solid core of ice, and a gaping rent in the side of the boiler showed that the shell had been burst along the whole length of one of the longitudinal seams.

The expansion of metals when subjected to the continued action of heat, as in the case of the expansion of water when subjected to cold, is practically irresistible. Thus the rays of the sun, acting down upon railway rails, cause the latter to expand, and unless space is provided at the joints, to permit expansion taking place, the rails will bend and curve and practically wriggle like snakes, as their temperature is increased.

Necessity for Provision against Expansion

Again, in the case of steam pipes, unless provision be made for taking up the elongation which is certain to occur when steam is turned into them, the forces of expansion are such that the pipes, if made of cast iron, will often snap. Also in structural-steel work one of the most important points to be considered by the engineer is suitable provision against these expansive forces.

Although, as stated in the foregoing remarks, the interatomic forces set up in the molecules of iron and steel are well nigh irresistible, yet it is not only possible to make suitable provision against these forces in the design of structures, but it is also possible to put them to practical use. Furthermore, sufficient knowledge has been obtained from investigation and experiment to permit calculations being made to ascertain the limits within which these forces may be usefully controlled. From experiments it is known with great accuracy how much a bar of iron or steel or other metal will expand when heated through a certain number of degrees. The force necessary to elongate such a bar through any given distance is also known within certain limits. Hence, knowing the range of temperature through which a bar is heated, or cooled, it is possible to calculate the stress which is set up in the bar when its free expansion or contraction is prevented.

Considering, for example, the case of a steam boiler 30 feet long whose temperature is raised from, say, 50 degrees, that of the cold water with which it is fed, to 350 degrees, that of the steam which it generates, corresponding to the pressure of, say, 120 pounds. Then the range of temperature through which the metal will be heated is 300 degrees. Taking the coefficient of expansion of mild steel as 0.0000067, the boiler will expand

$$30 \times 12 \times 0.0000067 \times 300 = 0.724 \text{ inch}$$

in having steam raised from cold water, and it will contract in cooling down again to the same extent. The modulus of elasticity of mild steel is about 30,000,000 pounds per square inch. Therefore the stress which will be set up in the boiler plates if these contract 0.724 inch by sudden cooling will be

$$\frac{0.724 \times 30{,}000{,}000}{30 \times 12} = 604{,}000$$

pounds per square inch, a force sufficient to rupture the metal of which the plates are made. This calculation, of course, assumes the boiler to be a rigid structure, which, however, it is not.

Enormous Stresses from Sudden Cooling

Some idea may thus be obtained of the severe stresses which are set up in steam boilers when cold water is run over the hot plates for the purpose of quickly cooling them for cleaning or inspection purposes. Where this objectionable method of cooling down is adopted, it cannot be wondered at if the seams begin to leak and give trouble, or even if a fracture of the plates results. No intelligent fireman having any idea of the enormous stresses produced by sudden cooling, would cool his boilers by playing cold water over the plates while the surrounding brickwork and other parts are hot.

The importance of providing against expansive forces is well seen in the case of steam pipes, particularly where superheated steam is used. The amount of expansion which takes place in a 100-foot length of steam piping when steam is turned on is usually about 2½ or 3 inches for ordinary steam pressures. With high pressures and superheated steam, it is considerably more than this. It will thus be obvious that in designing steam pipes, considerable expansive movements are to be provided for. Numerous devices are employed for this purpose, such as gland expansion joints, mild- or wrought-steel spring bends, copper expansion pieces, etc., and these, when properly designed and fitted, will be found effective in taking up the expansion which occurs.

An incident which might have had serious results occurred some years ago in connection with two boilers which were coupled together. An expansion gland joint was placed on the steam-pipe range between the two boilers, but owing to the fact that the joint was not provided with guard bolts, there was nothing to prevent the free end of the pipe from being drawn out of the gland should the expansion be sufficient. This actually took place, and as the end of the pipe drew out, one of the boilers, which was

empty at the time and was being examined, was gradually turned on its setting through a small distance, much to the astonishment of the inspector.

Liability of Fracture

In the case of steam engines, considerable expansion takes place under steam, especially with tandem engines. If the cylinders be rigidly bolted to the frame or beds so that expansion cannot freely take place, fracture of the cylinder feet or other parts is liable to result, and many breakdowns have occurred in this way. A simple method of avoiding this danger is to screw up the nuts of the cylinder-feet bolts against a ferrule, so that the feet may be allowed to move with the expansion but at the same time cannot be lifted from their seats.

Again, steam boilers must be carefully designed so as to accommodate the expansion which takes place under ordinary working conditions. A large Lancashire boiler 30 feet long will expand ¾ inch in having steam raised from cold water. This expansion frequently makes it difficult to prevent leakage of cold air into the flues; the movement of the boiler forces back the brickwork of the downtakes and a space is thus liable to be left between the back end plate and the brickwork through which cold air rushes and impairs the draft. The difficulty may be overcome by making the covers of such a form that they are capable of moving with the boiler as the latter expands or contracts.

Elasticity to End Plates

The furnace and flue tubes of a Lancashire boiler, being in direct contact with the furnace and hot gases, expand more than the shell. This throws a strain upon the end plates, which frequently leads to grooving at the place where the tubes are attached to the end plates. To avoid such grooving, the boiler must be so designed that these expansive movements are properly provided for, and the tendency to straining is thus reduced to a minimum. This is done by giving a certain amount of elasticity to the end plates, so that they are able to accommodate the expansion of the furnace and flue tubes. Hence, the end plates of modern boilers are made as thin and as light as is consistent with safety. Furthermore, no end gusset stays are carried down nearer than about 10 or 11 inches from the circle of rivets in the furnace angle irons or flanges, so as to leave a certain amount of breathing space. In this way, the ends of the boiler are made sufficiently elastic and flexible to take up the motion of the internal tubes as these lengthen and shorten due to changes in pressure and temperature within the boiler.

In building a steam-engine crank shaft, the crank is bored to a diameter slightly less than the boss of the shaft on which it is to be placed. It is then heated in a fire, and expands the diameter of the bored hole, increasing sufficiently to permit the crank being placed on the shaft. After placing on the shaft, the crank is allowed to cool, and as cooling goes on, contraction takes place and the crank grips the shaft so tightly that there is little possibility of its being moved afterward even under the heavy strains to which it is exposed during working. Flywheels, engine beds, etc., are frequently fastened together by hoops put on while hot, which, on cooling, make a very secure fastening.

Utility of Contraction

Again, the contractile force of cooling metals has been utilized by engineers for straightening the bulged or leaning walls of buildings. Long bolts with large washers and nuts are placed between the walls, the nuts and washers being screwed up until they bear against the walls. The bolts are then heated and consequently expand, and the nuts, which, of course, become slack through the lengthening of the bolts, are screwed up again. On leaving the bolts to cool, contraction results and the walls are thus gradually pulled to the required position.

Many other such instances might be cited, but sufficient has been said to show that engineers are not only able, by careful design, to provide against the forces of expansion and contraction, but they can, under certain circumstances, put them to actual practical use as pointed out.

Water Supply from Underflow of River

By C. W. Wiley

The accompanying photograph shows the discharge of over 2100 gal. per minute from a well only 44 ft. deep and 2 ft. in diameter. The discharge pipe is 8¼ in. in diameter, and the well could have easily supplied 50 per cent. more water than it did on the test had it not been for the limiting capacity of the pump and the small traction engine driving it. The head of water in the well was lowered only 15 ft. in supplying this large quantity of water.

The well is one of two supplying city water for Arkansas City, Kan., the supply being taken from the underflow of the Arkansas River.

The picture shows the results which may be attained by proper methods applied to well-work and furnishes an evidence that there is an almost inexhaustible source of clean, cool water in all river valleys having an underflow through sand beds. A similar well and pump have just been put in at Evansville, Ind., for the Evansville Public Service Co., to secure condensing water for its turbines. This well is 110 ft. deep and furnishes an abundant supply of water, the temperature of which is 56 deg.

Pump Working at Full Capacity

The underflow of the Ohio River is also very favorable for furnishing large quantities of cool water. Many cities in the Ohio Valley are using the river water and many power plants in such places are either running noncondensing or on low vacuums, due to warm condensing water, not realizing that an unlimited supply has been furnished below them.

Confessions of an Engineer

By R. O. Warren

Manager Wood believes that it is more economical to sell exhaust steam than it is to run the engines condensing.

Money is made by carrying out the idea and the engineer again sees where he could have made good.

It is said that one learns as he grows older. This may be true in some instances, but it did not seem to have been so in my case. The instance of the smoke-recording device did serve to make me look about the plant for something more that could be improved upon, but as nothing came to my immediate attention I soon lapsed back into normal conditions.

Another Jolt

Matters went on smoothly for a time until Wood gave me another jolt. He strolled into the engine room one afternoon and found me working on one of the tandem-compound engines. After the usual greeting he said, "How much steam goes to waste during a year, do you suppose?"

"Just what do you mean?" I inquired, with some surprise, for I had never given the matter a thought.

"About how much money are we throwing away that could be saved?" answered Wood.

Wood had me stumped for I had never made any attempt at keeping a record of what became of the steam after it was made. It was doubtful if I could have told how great the steam losses were, anyway. I certainly did not know how much water was used; I just pumped the water out of the pond and shoveled coal into the furnace.

Although I made a report of the amount of coal consumed each day and knew how many tons I used in a year, there were a good many sources for steam waste, now that my attention had been called to the fact, that could possibly have been stopped.

Continuing, Wood said: "Our conditions are the same as many other establishments. We operate the main engines during the day and a small engine during the night, so that there is considerable loss of exhaust steam, or would be if we were not running condensing during the 24 hours. The question is, is it cheaper to run condensing than it would be to run noncondensing and use our exhaust steam?"

"I suppose we could use exhaust steam for heating the shop," I replied, "as you know at present we run condensing and the live steam is used for heating purposes. If there is no other use for the exhaust steam, I do not see how you are going to utilize all of it."

Creating a Demand for Exhaust Steam

"What is the matter with creating a demand for the exhaust steam? Now there is the Knox shoe factory, which is motor driven from the central station; it could use exhaust steam for heating purposes if the price could be made attractive. As it now is, a boiler is kept under steam during the winter for heating and a small boiler for supplying steam for manufacturing purposes during the warmer months. Why couldn't we heat their shop for them?"

"Well, I suppose we could. About 70 or 80 per cent. of the steam taken from the boilers would go to the exhaust pipe, were we running noncondensing; well, perhaps a little less, taking the heater into consideration. Take this 500-hp. compound engine; it is using somewhere in the neighborhood of 15 lb. of steam per horsepower per hour, when cutting off at ⅓ stroke, with 100 lb. boiler pressure on the high-pressure cylinder. That would make—let me see—500 × 15 × 0.7 = 5250 lb. of steam that would go up the exhaust pipe each hour, and 5250 × 10 = 52,500 lb. of steam which would escape through the exhaust pipe in 10 hours. Of course, the night loss would be somewhat less."

Continuing the calculation, I said: "Take the small 100-hp. simple engine which we run at night and the steam consumption would be about 26 lb. per horsepower per hour, or 100 × 26 × 14 = 36,400 lb. of steam for the 14 hours' run. That makes a total of 52,500 + 36,400 = 88,900 lb. per each 24 hours' run."

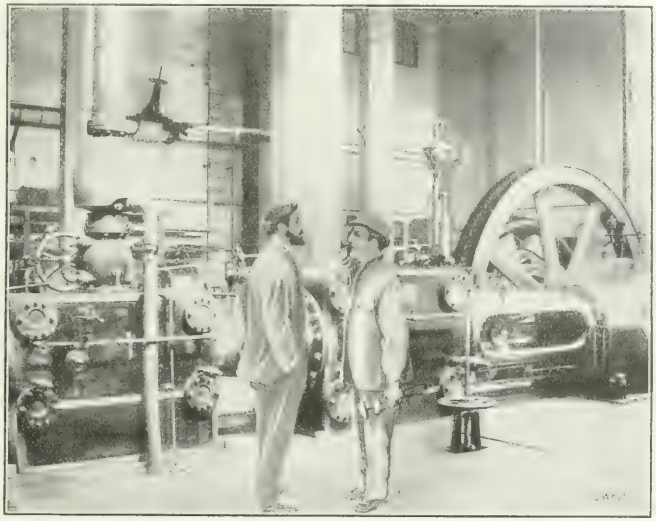
"Well, that would be worth saving, wouldn't it?" asked Wood.

Reaching Out for Consumers

"Why, yes," I answered. "Of course it would, but how are you going to do it? The Knox Shoe Co. does not want to use all of the exhaust steam we make, or could make, even if you could get it to shut down its boilers and discharge the two firemen."

"There is the Linden Shoddy Co. within a stone's throw of us. It runs by water power and uses steam in the process of manufacture. A boiler has to be kept in service for that purpose and a day and night fireman are each paid $1.70 per day besides the item of fuel, which amounts to about 1½ tons a day. This costs $6.15, and with the firemen's wages would amount to a total of $9.55 per day, the cost of running the steam end of the plant. I know this company could save money if it used our exhaust steam.

"Then there is the Brooks Machine Shop. Its power plant is about on its last legs and half of the shop is motor operated from our electric plant at the



Wood Found Me Working on One of the Engines and Wanted to Know How Much Steam Was Being Wasted

present. It would not cost much to run our exhaust-steam main to the Brooks plant and heat the place with the steam we are using in furnishing it with electrical energy."

"By George, I don't know but you are right," I exclaimed. "It is funny I hadn't thought of this myself. Why, it was way back in 1872 that the first system of the kind was installed up in Lockport, N. Y., and since then the idea has been so well advanced that now it is a regular business with some companies to make and sell steam for heating purposes alone, while others, such as electric-light and power plants, make a business of selling the exhaust steam to nearby office buildings, etc. The fact is that the business has been so advanced that one can purchase insulated piping, expansion joints, heaters, etc., without having them made especially for the purpose. All one has to do is to order the goods—and pay for them," I added, as an afterthought.

"Yes, I suppose these supplies, etc., have been made standard. Now, my way of figuring it is that there are from seven to eight months of the year when these three companies will want steam for heating purposes and I believe that there is a neat little business that can be obtained if we want it, and go about it in the right way."

"Of course, running condensing reduces the back pressure on our engines and running noncondensing and selling the exhaust steam would put from 2 to 10 lb. back pressure on the engine, which will necessitate a greater coal consumption for the same amount of power utilized in driving the factory."

"Ten pounds is pretty high back pressure," said I, looking wise.

Where Power Cost Practically Nothing

"Not so very much," rejoined Wood. "I see where they are running steam turbines in textile mills as reducing valves, taking steam from the second stage for the purpose of heating water, etc., and it has proven to be so economical that the power to operate the mill costs practically nothing, outside of the interest of the investment tied up in the turbines.

"My idea is to shut the condensers down during the cold months and sell the exhaust steam to these three companies. We have more engine capacity than we require and I do not believe that the slight back pressure will amount to very much when compared to the revenue that can be obtained from the sale of the exhaust steam. Another thing, during semi-cold weather, when there would be more exhaust steam than could be used, some of the engines could be run condensing and the exhaust-steam load kept at a point just sufficient to supply the demand.

"Of course there would have to be a live-steam connection from the boiler to the heating main, so that a steam supply could be had in case all of the engines were shut down at the same time. A reducing valve would have to be used to keep the steam pressure between the 2- and 10-lb. pressures. I guess that would about fix things."

"Not so fast!" I exclaimed, for as Wood's idea became evident I began to see where the details would fit in. "There will have to be a bypass around to the reducing valves, a back-pressure valve would be required in the atmospheric exhaust pipe and it will be necessary to have an oil and water separator in the underground pipe leading to the heating main, besides the necessary gages and recording devices. If you are going into this thing there is no use half doing it."

"Then there is the insulating of the steam pipe. There will be no use of running a lot of piping to these companies and then find that there is no steam to sell because it has all been condensed on its way to them."

Best Way to Lay the Pipes

"Huh! I hadn't thought of that. What do you consider the best method of laying the pipes? Of course, they will have to be insulated."

"There are several ways of putting in the pipes," I replied. "There are conduits in which the pipes are run and covered with insulating material, such as asbestos, hair felt, mineral wool, magnesium covering, cork and other materials."

Insulating the Pipes

"I remember reading some time ago that the best result according to tests were obtained from pipes which were covered with sheet asbestos and inclosed in round, tin-lined, white-pine stave casings, having a shell thickness of from 4 to 5¼ in. The interior diameter was sufficient to allow of an annular dead air space of not less than 1 in. between the tin lining and the asbestos covering. The pipes were held in place by means of guides on rollers."

"Sounds good, but I should suppose that the wood would soon decay from contact with the earth."

"No, you see it is coated with asphaltum and then rolled in sawdust. It is then covered with three-ply, extra-heavy tar paper. This protects the pipe from excessive electrolysis and reduces the heat radiation to a low degree."

"There will have to be extension joints and anchorages to make the system up to date. The more I think of it, the more I believe it will pay."

Where the Profits Came In

"Now, the Knox company has, according to its engineer, about 4000 sq.ft. of heating surface in its plant. We could afford to supply steam for about 0.0011c. per square foot per day of 24 hours, or, $0.0011 \times 4000 = \$4.40$ per day. At that rate, the company would make a profit, and without any trouble, of $5.15 each day. Worth saving, I should say. Of course the proper way would be to put in a suitable meter and then you would know exactly where you stand and how much steam each firm is using."

The upshot of the matter was that contracts were made, the piping and other necessary apparatus were purchased, and at the end of the next year Wood found that a neat sum had been collected from the sale of exhaust steam, so much, in fact, that the system was extended and the revenue increased until the system was fully loaded.

While Wood gave me credit for working out many of the details, the big thought was his, while it might have been mine just as well, and that is the way it goes with most of us.

Transmitting Power by Ropes

By Everard Brown

The amount of power that can be transmitted by a rope drive is limited, to a certain extent, only by the size of the installation. There are numerous drives of 4000 hp. that are running satisfactorily, while systems of from 1000 to 2000 hp. are quite common. For transmissions exceeding 4000 hp., however, the rope drive is not so generally used. A single rope, 2 in. in diameter and running at a speed of from 4000 to 4500 ft. per minute, will easily transmit 50 horsepower.

The speed and working tension are the two most important factors that determine the amount of power that can be transmitted by a given sized drive. The best practice as to speeds seems to be between 4000 and 5000 ft. per minute, although some as low as 2000 ft. have been used. It is hardly advisable, however, to exceed 5000 ft., for as the speed increases the available tension for transmission is reduced; in fact, at speeds over 4800 ft. per minute the centrifugal force increases faster than the power, due to the increased velocity. Furthermore, the wear on the rope is much greater at very high speeds because of the more frequent bending over the sheaves, thus causing internal wear by the rubbing of the fibers on each other. There is also a greater amount of slipping and wedging in the grooves of the pulleys. It is usually assumed that both of these causes of wear are directly proportional to the speed.

In calculating the power that can be transmitted by a certain sized rope it is common practice to assume that 1 lb. of tension on the slack side is equivalent to 2 lb. on the driving side and that the maximum strain advisable to put on

is about 200 times the square of the diameter of the rope. The centrifugal force must, of course, be deducted from the force available. This centrifugal force is found by multiplying the weight of the rope in pounds per foot by the square of the velocity in feet per second and then dividing this product by the force of gravity, or 32.16. Upon this is based the following formula:

$$A = \left(200d^2 - \frac{WV^2}{g}\right) \times \frac{2v}{3}$$

in which

A = Power in foot-pounds per minute, available for actual work;
d = Diameter of the rope in inches;
W = Weight of rope in pounds per foot;
V = Velocity of rope in feet per second;
v = Velocity of rope in feet per minute;
g = 32.16.

If the result is desired in horsepower, divide by 33,000.

Assuming, as an illustration, a 2-in. rope, which weighs about 1.4 lb. per foot, running at a speed of 4200 ft. per minute, the power that could be transmitted would be

$$\left[(200 \times 4) - \frac{1.4 \times 4900}{32.16}\right] \times \left(\frac{2 \times 4200}{3}\right)$$

$$= 1{,}639{,}750 \textit{ foot-pounds}$$

or

$$\frac{1{,}639{,}750}{33{,}000} = 49.69 \textit{ hp.}$$

In order to obtain the maximum arc of contact, the lower should always be the tight or driving side and the rope should be allowed to sag quite freely so that it will hang between the pulleys in catenary curves approximating parabolas. The distance between the sheaves may range anywhere from 20 to 150 ft., but for vertical drives they should be at least far enough apart horizontally to get proper adhesion.

Experience has demonstrated that the grooves in the sheaves incline toward each other at an angle of 45 deg., so that the rope cannot touch the bottom. The successful running of a rope drive also depends largely upon the sizes of the pulleys, which should never be less in diameter than 30 to 40 times the diameter of the rope.

The Continuous System

In this system, sometimes called the "American" system, the rope is continuous, being wound spirally around the driving and driven pulleys as many times as needed to transmit the required horsepower; then the last wrap is carried over a tension pulley and back to the first groove of one of the main pulleys. The tension pulley is usually mounted on a carriage so as to preserve a certain tension on the rope and to be free to take up any stretch. The driving and driven pulleys should be so placed that their grooves will be out of line one-half their pitch and, as there is no great tendency for the ropes to sway, the grooves may be made quite shallow; this will avoid severe chafing of the rope due to this side lead. It is not advisable to have them so shallow, however, that the rope will extend beyond the flanges.

In vertical drives, as well as those where the sheaves are close together, the continuous system has its advantages because under such conditions it is necessary to keep the rope relatively taut, which can easily be done by means of the tension pulley. Another advantage is that the ropes must necessarily revolve or turn in the grooves, a condition that seems to be desired as it results in even and uniform wear of the rope by preventing it from becoming wedge-shaped and thus shorten its life.

For the larger drives, however, particularly horizontal ones, where the distance between the pulleys is 40 ft. or more, this method of driving is not so generally used, one of the principal reasons for this probably being that it necessitates a very long rope to be carried as a spare and a suspension of operations until a new rope could be put on or the old one repaired should the rope break.

The Multiple System

The multiple, or so called "English," system is much simpler than the continuous system and is therefore more popular. It consists of one or several individual ropes working side by side, which necessitates, of course, many more splices than in the other method, but it has the advantage that, if one of the ropes should break, the load can usually be transmitted by the remaining ropes until closing-down time, when a new one can be put on; hence there need be no interruption or delay in operations.

A peculiar feature of the multiple rope drive is that frequently some of the ropes revolve in the grooves while others do not. There appears to be no explanation for this; it is the consensus of opinion, however, among men experienced with rope drives that the life of the rolling rope is from 15 to 20 per cent. greater than that of the nonrolling rope. This, it is claimed, is due to the nonrolling rope finally becoming wedge-shaped, and that the two sides thus formed by the grooves sustain the largest portion of the external wear. There are several ways of forcing a rope to revolve, one of which is to move it out of line one groove, or more if necessary, and another is to turn the drive slowly and twist the rope vigorously on the tight side as the driver is approached.

Splicing

No doubt most of the troubles encountered in rope drives are caused by bad splicing; therefore, too much attention cannot be paid to this point. It is absolutely essential for success with this type of power transmission that the diameter of the splice be the same as that of the original rope and that it be smooth and free from lumps. The original lay of the strands must be disturbed as little as possible and where the several strands are rejoined each fastening should be made in such a manner as to prevent its wearing away and the rope unstranding.

The number of strands to be used in a rope is a somewhat contested point. For small drives having rope of small diameter and subject to much bending, the three-strand rope is considered good; while for large drives the four- and six-strand ropes are preferred as they are more nearly circular and of greater cross-section, thus securing larger surface of contact in the grooves. The rope of four strands, however, has again a slight preference over that of six as it is not so difficult to splice.

Manila rope, especially for mill work, where properly proportioned sheaves can be used, no doubt gives better satisfaction than cotton rope. It is more durable, has a greater tensile strength and less stretch than the other. It is also more easily spliced and is considerably cheaper.

Manila Rope

The following information relative to the source of manila rope might be of interest:

It is made from the fiber of the abaca plant, which grows only in the Philippine Islands, and the trunk of which somewhat resembles that of the banana tree. This trunk is closely covered by long leaves from which the fiber is procured in lengths ranging from 5 to 10 ft., and sometimes as long as 18 ft. The tensile strength of the fiber is remarkable only when subjected to a longitudinal strain as, transversely, owing to its cellular formation, it is comparatively weak. It is, therefore, quite essential in manufacturing the rope to exercise the greatest care to secure the right amount of twist, etc., in both yarns and fibers so as to avoid any crosswise strains, and also to prevent as much as possible the wear and tear resulting from the rubbing of one strand upon the other while passing over the pulleys.

A Montreal syndicate, it is reported, has prepared plans for a million-horsepower hydro-electric development near Montreal. It is proposed to divert the whole course of the St. Lawrence River at Coteau and Cedar Rapids. The cost of the dam will be $25,000,000, and the syndicate's capitalization is said to be $100,000,000. To pay dividends on this enormous sum will require the development of nearly one-half million horsepower.

Application of the Arithmetical Mean

By Julian C. Smallwood *

The arithmetical mean as applied to engineering observations and some of the errors resulting from its indiscriminate use.

*Associate professor of experimental engineering, Syracuse University

There are two distinct conceptions of the arithmetical mean. For example, when referring to the mean effective pressure of a steam engine, it signifies a single quantity that represents or replaces a series of varying values of the steam pressure. The process involved is theoretically without error, for if a rectangular indicator diagram be constructed having the mean hight of the actual one, the area obtained from it will equal the area of the actual diagram. What is done is to replace for a varying quantity a constant one which produces exactly the same result. The process has, of course, unlimited applications.

On the other hand, the problem may deal with a number of discordant results obtained from various measurements of a single constant quantity. For example, under exactly the same conditions of load and running, and using the same care in making measurements, the water rate of a steam engine may be variously determined. One is forced to the conclusion, then, that some accidental errors in measuring have occurred and these account for the variation of the results. There is, however, no reason for believing that any one of the results is more doubtful than the rest. Under these circumstances, the most natural course is to take the mean of the determinations; that is, to divide the sum of the results by the number of determinations, and to consider this result as the best one obtainable from the data. This is not only the most natural procedure; it is obviously correct. But if asked why it is correct, it will be difficult to obtain a satisfactory answer. To prove it unaided will probably be impossible.

Substantial causes for doubt of the arithmetical mean may easily be found. Suppose calculations have been made for the same quantity, using a slide rule from which could be read three significant figures, these determinations and their mean being as follows:

3.96
3.99
4.00
3.98

4)15.93
3.9825

That is, a result has been obtained having two more decimal places than any of the single measurements. But, as stated, the limit of accuracy of the instrument is the second decimal place; hence, the question arises as to whether any confidence may be placed in the 0.0025 of the result. The question cannot be answered offhand. It may be answered, however, by first calculating the probable error of the mean.

Consider a case in which the arithmetical mean is wrongly applied. Referring to Fig. 1, suppose that the points *A* and *B* have been measured from X and that, as a check, the distance between *A* and *B* has been measured. The determinations are 20 feet, 22 feet and 3 feet, as shown, and therefore the results do not agree. There is, however, no reason for doubting any one of the measurements more than the rest. Therefore, it is desirable to modify them so that the most accurate result will ensue. It seems obvious that the arithmetical mean may be used, and one will naturally take as the determinations of the position of *A*,

$$(20 + 22 - 3) \div 2 = 19.5 \text{ feet}$$

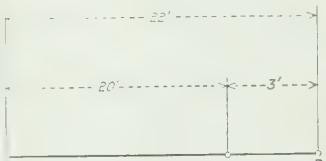


FIG. 1.

as the mean. Similarly one might take for the two locations of *B*, 22 feet and 20 feet plus 3 feet, in which case the mean is 22.5 feet. But by this method of adjusting the values there is no correction of the distance *A B*, which is still 3 feet. One might adjust the data in the same way so that there will be no error in the measurement of *X A* or of *X B*. Which set of values, then, should be selected as approximately correct?

There is only one way of adjusting such data and that is by the method of least squares. The location of *A* obtained by first measuring *B* is indirect and to such measurements the arithmetical mean does not apply. The lesson to be learned from this example is that when adjusting data to get the most accurate result the arithmetical mean applies only to direct determinations upon a single quantity. This use, however, must not be confounded with the other purpose of the mean, previously considered.

It might be well here to point out a mistake that is often made in calculating the arithmetical mean. Sometimes it is necessary to obtain the mean of a large number of quantities which have been arranged in groups, already averaged, such as the following:

51	52
52	53
53	54
54	55
55	56
	57
5)265	6)327
53	54.5

The mistake referred to consists in getting the total mean, thus

$$(53 + 54.5) \div 2 = 53.75$$

Clearly this is incorrect, because

$$(265 + 327) \div 11 = 53.82$$

This mistake is caused by averaging the averages of groups having unequal numbers of the quantities averaged. If the groups contain the same number of quantities the process is a correct short cut.

Another very common mistake made in averaging is to include in the quantities averaged one or more of doubtful value. Consider, for example, four tensile tests upon the same steel resulting as follows:

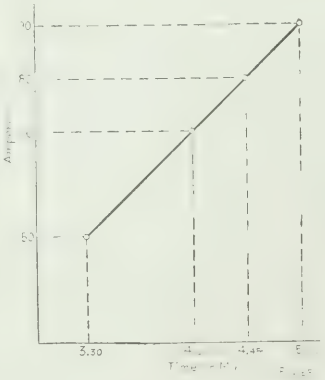


FIG. 2.

60,000 pounds
61,000 pounds
62,000 pounds
33,000 pounds

Mean value 54,000 pounds

This result is unfair to the material. It would be a natural inference that because the last specimen failed at so much less load than the other three, it was defective. If this result is omitted the mean will be 61,000 pounds. In general, then, one must examine and compare results that are to be adjusted and cast out or modify those whose peculiarities can be accounted for by circumstances not applying to all of them. If this is not done the arithmetical mean may have no significance whatever. As a rule, for adjusting determinations it

must be applied only to those quantities which are equally reliable and subject to the same accidental causes of error.

Another improper calculation of the arithmetical mean is due to lack of consideration of the element of time. Suppose readings of an ammeter registering

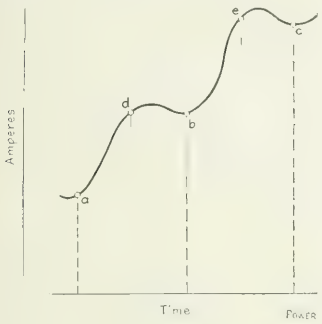


FIG. 3.

a uniformly increasing current are taken. Fig. 2 represents the actual variation of the current, amperes being plotted against time, such as would be obtained from a recording device. The actual mean amperage is then the mean hight of the curve, or 70 amperes. If no recording device is used and readings are taken by an observer at irregular intervals of time, such as are indicated, the resulting mean would be

$$290 \div 4 = 72.5$$

It is evident, therefore, that such observations should be made at uniform intervals of time.

that the more determinations that are made of a desired quantity, the more precise is the mean resulting from them.

There are many cases where the rule of the mean, as used to obtain a single quantity representing a varying one, is theoretically wrongly applied, yet the error introduced into the result is negligible for practical purposes. In the use of the throttling calorimeter, for example, the quantities from the steam tables corresponding to each set of thermometer readings should be substituted in the heat equation and the resulting values of the quality averaged. The common method of averaging the observations and applying the heat equation only once for all of them yields a somewhat erroneous result. Generally, in such a case, the smaller the variations in the readings, the less the error involved in the use of the mean.

What has been so far adduced goes to show that certain uses of the arithmetical mean lead to wrong results. There are also other cases wherein it is doubtful how it should be obtained. In this connection, consider a series of determinations made for the quantity of water discharged as measured by a venturi meter. This instrument gages the flow of water through a pipe by the difference in level of a water or mercury column. The formula is of the form

$$Q = K \sqrt{h}$$

Q being the quantity in cubic feet per second; K, a constant depending upon the instrument, and h the reading from the U-tube employed. This and similar forms of equation are used in a vast number of engineering calculations. With a number of readings of h and wishing to obtain a mean value of Q, one may get two different results, depending upon whether one first averages all the values of h and substitutes their mean in the equation or substitutes each value of h in the equation and then calculate the mean of the resulting values of Q. The difference is that between taking the square root of the mean of a number of quantities or the mean of the square roots of the quantities. To determine which is the better procedure it is necessary to determine the conditions of operation. First, assume that the rate of flow is absolutely constant. The variation is then due to errors in the records, either through the imperfect sight of the observer or through accidents influencing the manometer external to the rate of flow. Clearly, then, the readings should be averaged, because by doing so a more precise result is obtained to represent the quantity in which there is supposed to be error.

If, however, it is known that a high degree of precision has been maintained in the observations, and that the rate of flow fluctuated, the rate at the time of each reading may then be considered to be exactly the quantity calculated from that reading. In this case, the rates should be averaged, and not the heads.

Enough has now been presented to convince the reader that the rule of the arithmetical mean may not be applied without careful consideration and that serious error may follow its indiscriminate use.

Locomotive Came to Grief

The extent to which coal mining is carried on long ago necessitated the abandonment of mules for transporting purposes and the adoption of narrow-gage locomotives in their stead. In fact, the progressive mine cannot well do without them. Occasionally these little locomotives come to grief and are wrecked as completely as are the larger ones on trunk lines.

The illustration, Fig. 1, shows a type of these locomotives which can be found in almost any mining community. Fig. 2 shows what is left of an engine which, due to carelessness or confusion on the part of the engineer, ran off the end of a culm-pile track, wrecking itself as shown, and demolishing with other pipes a 14-in. steam line.

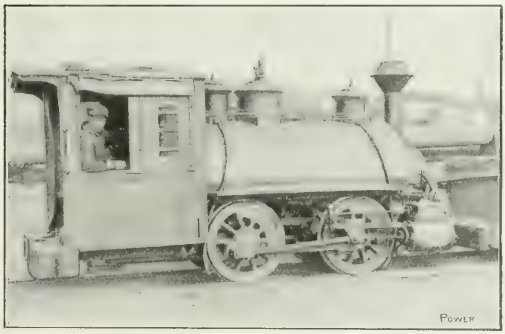


FIG. 1. TYPICAL MINE LOCOMOTIVE

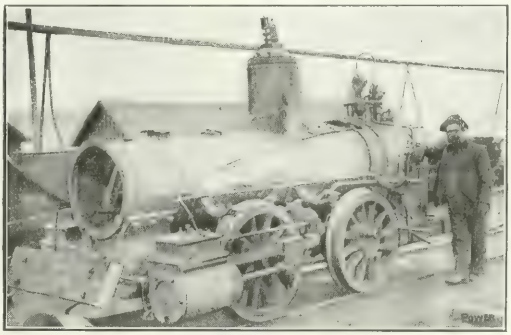


FIG. 2. AFTER AN ACCIDENT

A Proposed Basis for Coal Purchase

By John P. Cosgro

These specifications are compiled on the assumption that the available heat, or what has been called for convenience "commercial effect," in a unit of coal when hand fired either in a gas producer or under a steam boiler is not proportional to the total combustible content, but is practically dependent for its value on the fixed carbon modified by the percentage of ash and moisture.

The United States government for some purposes is buying coal on a B.t.u. basis as determined by coal calorimeter tests, but as this gives the accurate value of coal only when burned under ideal conditions it is not an accurate measure of its commercial value.

This statement is based on the results of tests by eminent authorities and on personal experience, which indicates that the volatile combustible matter in coal burned under even the best commercial conditions is so easily lost by imperfect combustion that the fixed carbon may be taken as the principal useful element.

It is not true that 1 per cent. of moisture is as detrimental as 1 per cent. of ash in the coal under all circumstances, nor that a reduction of one unit of either is equivalent to the addition of 1 per cent. of fixed carbon, as these are all variable factors; but ordinary practical operation gives results closely approximating these values and a simple working formula for comparing the commercial value of different coals is obtained by such an assumption.

If the provisions of the specifications are enforced, they will insure that the coal furnished will be of a uniform quality, or, failing this, proper adjustment will be made. They will also encourage the dealer to maintain or enhance the quality of the shipments by offering him a bonus for an increased percentage of fixed carbon or a decreased percentage of ash and moisture.

While the gain to the purchaser will be in a slightly increasing ratio to the amount of bonus paid, the dealer will not be the loser thereby. In other words, the dealer gets paid for exactly what he furnishes, while the buyer pays only for what he gets but gains by having less waste matter in the coal.

It is not expected that the proposed system will meet with the unqualified approval of the coal producer at the start as it limits him rather closely at a point where he has hitherto been free to ship an inferior grade with no fear of being penalized.

To coal companies which have confidence in the superiority of their product and which desire to trade on a strictly business basis, this method offers many advantages, as the price they receive per ton is controlled by the grade of coal supplied, limited, of course, by the provisions of the specifications, and it is believed that once the arrangement is made clear to any coal company looking for business, no difficulty will be experienced in getting it into line. The method of putting this system into operation would be to have a coal company submit either a standard sample or a statement of the fixed carbon, ash, moisture and sulphur content of the coal they propose to furnish under the terms of the specifications which would be made a part of the buying agreement together with prices, tonnage and shipping facilities. In some cases where the coal dealers have a monopoly it will be necessary to use considerable care in getting the system into operation, but a large consumer should have no great difficulty in effecting an agreement along the lines laid down. Where competition is keen the provisions of the specifications should be rigidly enforced, as the conditions are entirely equitable.

It may be advisable to send a representative to visit any accessible coal fields for the purpose of determining the best economic grade to be adopted as a standard, get an idea of the facilities of the company for furnishing a continuous supply, and possibly to establish working relations on a friendly basis.

The matter of sampling will, of course, require some threshing out before a working arrangement is agreed upon, but when it is considered that practically all metal mines dispose of their product along similar lines, no serious difficulty need arise.

The expense of making the necessary proximate analyses will be comparatively slight, and the sampling can be supervised by the engineer or some other qualified person.

Proposed Standard Coal Specifications

It is the intention of these specifications to provide for the maintenance, within reasonable limits, of a uniform percentage of fixed carbon, ash, moisture and sulphur in the coal furnished hereunder by (a) establishing a standard percentage in the case of the first three constituents and paying a bonus for an increased percentage of fixed carbon or a decreased percentage of ash or moisture; (b) by penalizing in the same ratio a decreased percentage of fixed carbon or an increased ash or moisture content; (c) by putting a limit on the maximum acceptable percentage of sulphur; (d) by establishing a rejection limit of 10 per cent. above or below standard.

Standard Grade

The standard grade to be taken as a basis for settlement is to be that quality of coal forming the base of the buying agreement and on which the standard price is fixed, the numerical value of which will be the "commercial effect" as defined in the following paragraph.

"Commercial Effect"

It is assumed that ash and moisture are equally detrimental in the fuel and that a reduction of 1 per cent. of either constituent is equivalent to an increase of 1 per cent. of fixed carbon; therefore what will be termed for convenience "commercial effect" in a shipment of coal will be determined by subtracting the sum of the ash and moisture in percentage from the percentage of fixed carbon in the coal. Thus:

Commercial effect = per cent. fixed carbon — (per cent. ash + per cent. moisture)

For instance, assume the buying agreement to be based on a coal of the following composition:

	Per Cent.
Fixed carbon	60
Ash	12
Moisture	5

Then

$$12 + 5 = 17$$

and

$$60 - 17 = 43 \text{ } \textit{commercial effect}$$

which, in this case, is also the unit of standard grade or standard commercial effect, as the buying agreement was predicated on coal of this quality.

Settlement

As the conditions under which this coal is to be used favor a high percentage of fixed carbon and a low ash and moisture content, a *pro rata* settlement will be made on each car lot, providing a bonus or a penalty accordingly as the commercial effect of the shipment compares with the standard commercial effect. Thus assuming the buying agreement to be based on coal of 43 per cent. commercial effect at $5 per ton and that shipments showed the following composition:

	Per Cent.
Fixed carbon	62
Ash	11
Moisture	3

$$\textit{Ash + moisture} = 11 + 3 = 14$$

$$62 - 14 = 48 = \textit{commercial effect}$$

Then the settlement basis equals

$$\frac{48}{43} \times 5 = \$5.58 \textit{ per ton}$$

Again assuming the same standard grade and price, the shipment shows composition as follows:

	Per Cent.
Fixed carbon	58
Ash	14
Moisture	4

$$\textit{Ash + moisture} = 14 + 4 = 18$$

$$58 - 18 = 40 = \textit{commercial effect}$$

Then the settlement basis equals

$$\frac{40}{43} \times 5 = \$4.65 \textit{ per ton}$$

Sampling

Each car of coal shall be sampled separately and an individual settlement made thereon; a sample of approximately 100 lb. per car will be taken during unloading, care being taken to secure pieces representing the average quality of the shipment. This sample will be broken and divided to about 10-lb. pieces which will be reduced to 40 mesh for proximate analysis on the results of which the commercial effect will be calculated by the above method and settlement will be made in accordance therewith.

The process of sampling and analysis shall at all times be open to representatives of the coal dealer and of the buyer, and each party shall receive a sufficient sample for check analysis and a further sample shall be placed in a sealed, stoppered jar for future reference until the settlement is made.

Rejection Limit

The constituents of fixed carbon, ash and moisture shall not vary to exceed 10 per cent. above or below the standard grade in any car lot and a variation in excess of this amount shall be considered just and sufficient cause for the rejection of shipments at the purchaser's option and the coal company shall reimburse the purchaser for freight paid on any shipment rejected under this clause.

An excess of 1.5 per cent. of sulphur will also be considered sufficient cause for rejection of any shipment subject to the same conditions as above.

Proposals

Parties bidding on coal under these specifications are requested to forward to the purchasing agent a proximate analysis of the grades they are prepared to furnish, together with the maximum and minimum tonnage they agree to supply under the terms stated herein, also to describe in detail any suggested departure whatsoever from these specifications, together with their reasons therefor.

Electric Traction in London

An idea of the growth of electric traction in London may be gained from the following account of the work of the London county council. This council was constituted under the local government act of 1888, its administrative area being over 120 sq.m., and one of its most important committees, the highway committee, has supervision over the tramway system.

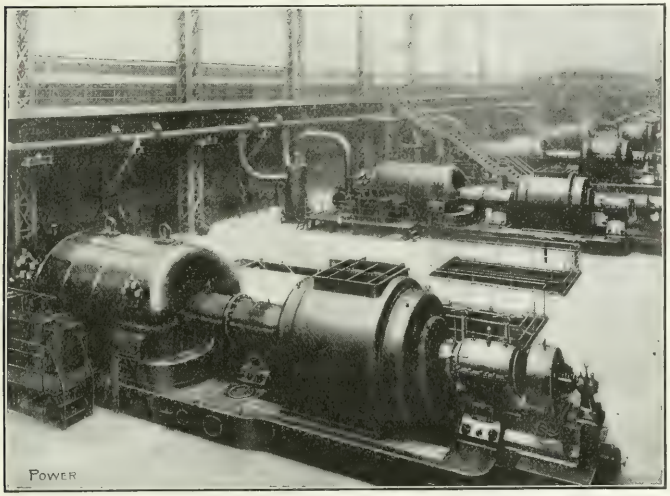
The London County Council Tramways consists of what was formerly a number of independent tramway undertakings operating within the county of London, together with certain new lines subsequently built by the council. Each of these companies owned from 4 to 50 miles of line, but gradually the council has taken over by purchase all the tramway companies within its area. The first transfer took place in 1895 and the last in 1909.

At the end of March, 1910, the system extended over 135½ miles of street, of which 115½ miles were electric lines. The remaining 20 miles were at that time still worked by horse traction, but the latter have now practically all been converted to electricity.

The accompanying table indicates the progress which has been made with the work of electrification. In some years it will be observed that while the amount of electrified lines increased, the length of horse lines also increased. This is accounted for by the acquisition by the council of other tramway undertakings.

	Electric traction in operation: Street miles	Horse traction: Street miles	Total Street miles
March 31, 1904	19¼	69⅝	88⅞
March 31, 1905	26⅝	68⅜	95¾
March 31, 1906	30⅜	73⅝	104
March 31, 1907	58⅞	57⅞	116¾
March 31, 1908	68⅝	51¾	120⅜
March 31, 1909	84⅜	54⅛	129½
March 31, 1910	115½	20	135½

The total capital outlay of the London County Council Tramways amounted on Mar. 31, 1911, to about $50,000,000.



Main Turbine and Engine Room of Generating Station

Generating Station

The electric-generating station for the whole tramway system of London is situated at Greenwich, close to the River Thames. It was erected in two sections, and the site covers an area of approximately 3¾ acres. The plant contains four vertical reciprocating engines coupled to three-phase generators, of 3000 kw. capacity each, and four three-phase turbo-generators each of 5000 kw. capacity. Two of the latter have only recently been installed. They were manufactured by the British Westinghouse Electric & Manufacturing Co. and are shown in the accompanying photograph.

The normal capacity of the Greenwich generating station is 34,000 kw. The current is generated at a pressure of 6600 volts and is conveyed to various substations over the tramway area. The substations are provided with motor-generators and rotary converters having a total capacity of 45,750 kw. transforming the current from alternating to direct at from 550 to 600 volts.

Paraffin Motor Driven Launch

A motor launch has recently been built to the design of John I. Thornycroft & Co., London, for use in Australian waters, especially designed for both pleasure cruising and carrying bales of wool. Hatches are fitted over the stern tubes and propellers to facilitate inspection, and are made large enough to admit 34-in. bales in case of emergency.

Her length is 60 ft., with a 10-ft. beam and a draft not exceeding 18 in. She is equipped with two sets of Thornycroft six-cylinder 4½x6-in. paraffin motors, developing 45 brake horsepower, and has a speed of 13 miles per hour. The main fuel tanks are of 60 gal. capacity. A large dynamo set driven from the main engines furnishes current for a powerful searchlight, the ventilating fans and general illumination.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Hydro-Electric Irrigation Project

By H. B. McDermid

In the southeastern part of Idaho, lying on both sides of the Snake River, is the Minidoka project of the United States Reclamation Service. There are now under the ditches about 120,000 acres of land, served by several hundred miles of irrigation canals, operating for the most part under the gravity system. There is, however, a considerable acreage in that locality to which water can be brought only by a pumping system, about 50,000 acres now being supplied by three pumping stations operating in series. Each of these has a lift of 31 ft., the first taking its water from the main south-side gravity canal, at a point some 15 miles from the dam; the second, taking its suction from the discharge canal of the first station and at a point about a mile from the latter and delivering to the third level; half a mile further on, the third station takes its suction and raises another portion to the fourth and final level of the development as at present completed.

The power for these stations is furnished by the generating plant at the dam, some 15 miles to the northeast, from which it is transmitted at 33,000 volts. The capacity of the hydro-electric installation is 10,000 hp., practically all of which is utilized by the pumping stations mentioned.

Hydraulic Features

The dam, which serves both to divert the water for the two main gravity canals, one on each side of the river, and to furnish power for the pumping plants and the towns within the project area, is six miles southwest of the village of Minidoka on the Oregon Short Line, this station being the nearest shipping point.

The out-cropping lava-rock ledges, so prevalent in this locality, have been taken advantage of by the engineers in building the dam, and particularly the spillway shown in Fig. 1. A sinuous ledge of rock stretching across the valley has been utilized to form a portion of the retaining walls, thus affording a bed-rock foundation for all concrete work and effecting a considerable saving in the amount of concrete used over that which would have been necessary had the dam and spillway been built straight across the deeper portions of the valley.

In choosing the power-house equipment, several points had to be carefully considered. First of these was the normal efficiency of the turbines chosen at the head of 46 ft. Since the beginning of the official gaging of the river, it has been known to have a minimum flow less than that required for the present development, and not only must the government adopt all means to protect the water rights of the settlers it has induced to take up land there, but the prior rights of other irrigation projects farther down the river must also be supplied. Except for a short period in the summer season, this has so far been completely taken care of by ample pondage resources and the supply for the past seven years has been more than sufficient. This positive requirement is of advantage at the Minidoka dam as it insures a minimum amount of water available for power purposes of approximately 3000 cu.ft. per second as long as the natural flow of the river reaches that amount. Second, machinery had to be selected which would occupy the least floor space, as the space available was fixed by the penstock openings in the dam and horizontal units would have required a much wider building. This would have greatly increased the cost because the power house is situated in the middle of a large arid region several miles from the nearest railroad, with no dependable supply of labor available and with excessive cartage costs. A third factor governing the choice was that of the reliability of the apparatus, it being necessary to keep up the service at all times without interruption.

A careful study of these conditions resulted in the adoption of the vertical type of unit, the snail-shell type of hydraulic turbine, with sheet-steel casings, because of the high efficiencies obtainable under the moderate head conditions and the durability of the material, and, third, the installation of sufficient spare apparatus to enable continuous operation through a period of interruption.

The apparatus consists of five main units arranged as shown in Fig. 2, each unit being capable of developing 2000 hp. under normal conditions, and having an independent transformer. Each unit also has its own governor so as to secure accurate and separate control. Two duplicate exciter units, each sufficient to furnish excitation for the whole system, are installed.

Fig. 1. Portion of 2600-ft. Spillway

The turbines driving the main units are fed by 10-ft. penstocks leading through the vertical wall of the dam, which forms one side of the power house. These penstocks are furnished with large motor-operated gate valves of the single-seat type, which are controlled from the main operating floor, directly in front of the unit whose penstock is controlled thereby. During the operation of opening a main gate, a small filler gate acting as a sort of pilot valve is also opened and the turbine and its penstock are filled, thus equalizing the pressures on each side of the main gate so that it can be raised more easily.

When the filler gates reach their full open position, they engage with a heavy

boss on the main gate and at the same time automatically throw out a limit switch, stopping the hoisting motor. The first three notches of the controller are so wired as to bridge over this first limit switch so that when a "telltale" pipe shows that the turbine case is filled, the operator may again start his motor. This again raises the valve stems, which, as they now solidly engage with the main gate, raise the latter to its full open position, when a second limit switch is automatically thrown, thus cutting off all current and making overrunning impossible.

On lowering the gate the main gate closes by gravity, after which the filler gates close as the stems proceed on their downward travel. A glance at the sketch (Fig. 3) should make the design of the two gates clear; the whole apparatus being so designed and installed as to automatically eliminate danger from careless operating. As a further precaution, a suitable weight-and-pulley device connected to the gate and having its graduated scale directly in front of the operator is installed, thus permitting him to see at a glance the position of the main gate at any time.

The turbines are of the Francis type, with 52½-in. runners, controlled by wicket gates. They are guaranteed to operate under a normal head of 46 ft. with a maximum efficiency of 81.5 per cent.; to maintain an average efficiency of 77 per cent. from half to full gate openings, and to deliver 2000 b.hp. at the stated head. In practice, however, they are capable of delivering 2060 b.hp. and the efficiency guarantee has also been exceeded.

The sheet-steel casings are heavily stayed throughout and are rigidly supported on heavy concrete foundations which permit them to operate with minimum jar and vibration when running at their normal speed of 200 r.p.m.

The arrangement of the draft tubes is worthy of notice. In building the dam large sluice gates to take care of the overflow were installed in each main bay directly back of the draft tubes. As there might be serious risk of injury to the draft tubes if a sluice gate were opened while they were in place, an overhead trolley is arranged over each of the 10,000-lb. steel draft tubes (see Fig. 4), so that they may be detached and run out of the bay and under swinging wall cranes mounted on the down-stream wall of the power house, thus being raised up and swung around, entirely free from all danger of injury when the sluice gates are opened.

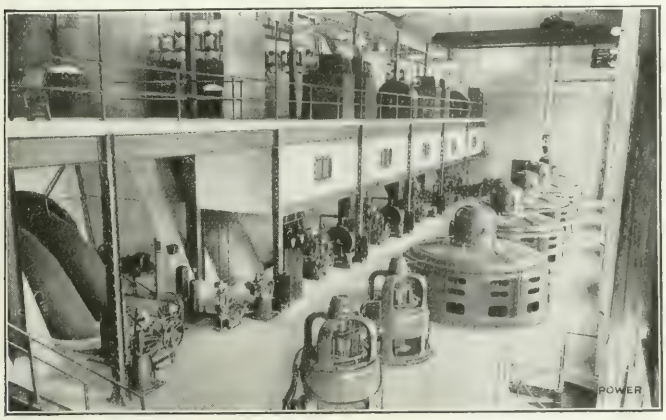


FIG. 2. MAIN GENERATOR ROOM AND SWITCH GALLERY

ing sufficient capacity to supply the whole station, while a second pumping unit is held in reserve.

Both these pumps are of the cycloidal type, their working parts being limited to two gears running together in a casing with the minimum possible working clearance. The oil is drawn up from the suction openings into the spaces between the teeth of the gears, and is there held by the closely fitting casing until it emerges into the discharge opening where it is prevented from escaping by the meshing of the teeth. A glance at Fig. 7 will make this design clear.

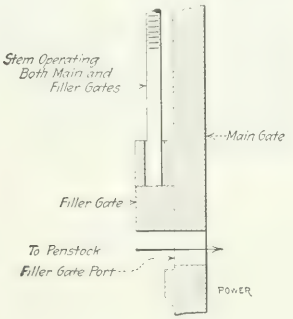


FIG. 3. SHOWING DESIGN OF MAIN AND FILLER GATES

From the pumps, whose absence of valves or other small parts renders them almost immune from operating troubles, the oil is led to a pressure tank of about four barrels capacity, capable of withstanding a working pressure of 250 lb. per square inch. Normally, the upper half of this tank is filled with air which serves as a reservoir of energy, by which means the flow of oil may be rapidly accelerated to any point in the line should sudden demands be made upon the system. Since the oil pumps are of the constant-capacity type,

FIG. 4. DOWN-STREAM SIDE OF POWER HOUSE, SHOWING DRAFT TUBE REMOVED

REGULATION

Each unit is regulated by an oil-pressure governor the operating cylinder of which is coupled to the wicket gates of the turbine by rigidly connected links and levers. (See Figs. 5 and 6.) The regulating cylinders are supplied with a medium-weight engine lubricating oil at 175 lb. pressure by a gear pump hav-

a relief valve is placed upon the pressure tank which opens at any predetermined pressure and automatically discharges any excess oil to the large exhaust header, conveying all oil exhausted from either the governors or the pumps to the storage tank in the basement. After it has been strained and cooled, the pump suctions take their supply. In normal operation, the oil from the pressure tanks flows into a long pressure header running the whole length of the five units, from which risers are taken off to supply each governor, the exhaust from which is conveyed through a similar header to the storage tank in the same manner as the exhaust from the relief valves.

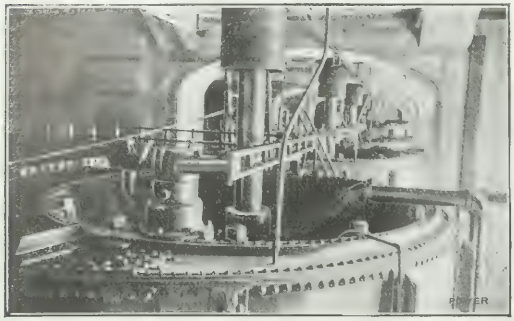


FIG. 5. SHOWING METHOD OF CONTROL ON MAIN UNITS

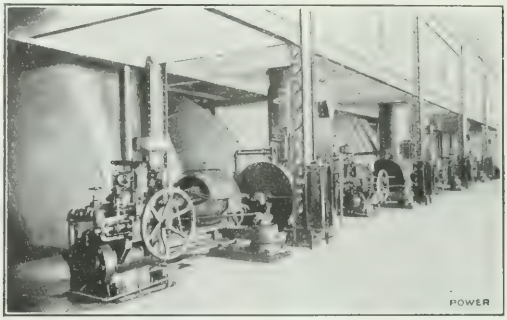


FIG. 6. GOVERNORS AND OIL PUMPS

ELECTRICAL EQUIPMENT

The main generators are of the mushroom type, furnishing 60-cycle, three-phase currents at 2300 volts. Their normal rated capacity is 1400 kv.-a. at a speed of 200 r.p.m. with a guaranteed efficiency at full load of 96 per cent. Each is direct connected to its turbine by a clamp coupling and carries upon its frame at the top of the shaft the thrust bearing which supports the 21 tons of revolving parts. This is a plain collar bearing running in a simple water-cooled oil bath, which operates without attention.

The transformers, which are located in the gallery, are air-cooled and are each rated at 1400 kv.-a. These step up the current from 2300 to 33,000 volts. It is then conveyed by duplicate sets of busbars to the remote-controlled oil switches. These switches on the high-tension circuits furnish the means for synchronizing the main units, there being no switches provided on the low-tension side of the transformers. From these switches the current may be delivered from either set of busbars to either of two transmission lines, each provided with a set of electrolytic lightning arresters. The remote-control switchboard is shown in Fig. 8, and Fig. 9 shows the disconnecting and oil switches.

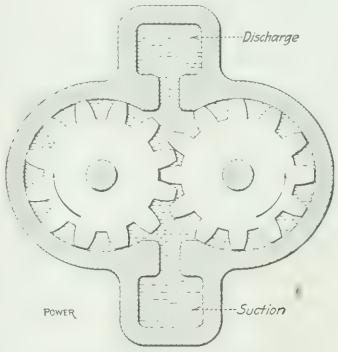


FIG. 7. SECTION THROUGH GEAR PUMP

The exciter units are driven by 180-hp. turbines of the same general type as the main units, and are furnished in duplicate throughout.

LUBRICATION SYSTEM

A storage tank, situated near the upper entrance of the power house, well above the bearings to be oiled, contains a supply of oil which is led to the different units in brass pipes, and after running through the bearings is collected by centrifugal oil throwers which discharge into circular catch basins surrounding the shafts of the main units. From these, drain pipes convey the oil to a filter, where it is again pumped to the overhead storage tank by a small motor-driven cycloidal pump. This motor is stopped and started by a float-operated switch, and the entire apparatus demands but little attention. A single stop-cock, to be opened or closed as the machine is started or stopped, controls the lubrication of the main steady bearings of its unit, except the turbine steady bearing which is fed by grease cups.

The turbines, thrust bearings on top of the generators, air-blast transformers and centrifugal pumps were furnished by the Allis-Chalmers Co., the generators, motors and other electrical apparatus by the Westinghouse Electric & Manufacturing Co., and the head gates by the S. Morgan Smith Co.

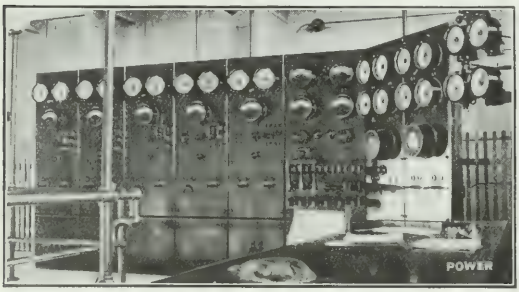


FIG. 8. REMOTE CONTROL SWITCHBOARD

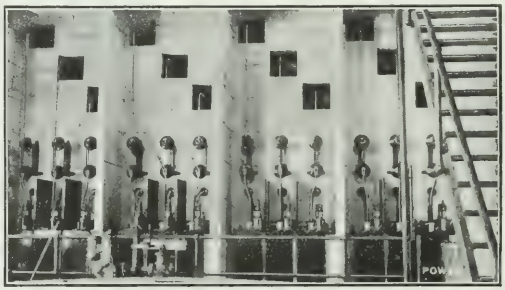


FIG. 9. HIGH-TENSION SWITCHES

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Foos Ignition System

The Foos Gas Engine Co. has abandoned the use of batteries and other independent sources of ignition current, and placed its entire dependence on a magneto which is attached permanently to the engine frame as shown in the accompanying picture, Fig. 1. The magneto is practically an integral part of the engine—just as much so as the governor, lubricator or other devices which though not component parts of the power-developing structure are indispensable to its operation and may be regarded as "integral" auxiliaries.

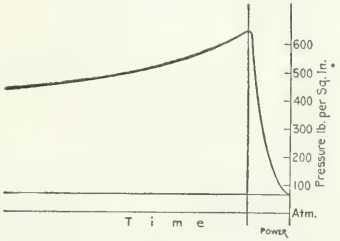
As the illustration indicates, the magneto is gear-driven from the half-time gear of the valve-mechanism shaft. It is made unusually powerful in order to enable it to give sufficient voltage to form a good ignition spark at the slow speed obtained in turning the engine over for starting up. The field magnet is made up of six permanent magnets, each ⅝ x 1½ in. in cross-section, and the armature core is laminated, like that of a high-grade electric motor or generator. The electrode being given a continuous rotary motion instead of the usual oscillating movement. Fig. 2 illustrates the construction; the spindle of the rotating electrode carries a contact blade set so that its contact edge is eccentric with respect to the axis of the spindle, and as the latter revolves, the blade wipes the tip of a flat spring which constitutes the other electrode of the igniter. This arrangement has two obvious features of merit: the wiping contact keeps the electrodes free from deposits of carbon or other objectionable material and the release of the spring by the travel of the stud causes the former to open the circuit with a sudden snap conducive to maximum vigor in the resulting spark.

Explosive Pressures in Gas Engines

By G. W. Munro

The reports of the increasing number of gasoline-engine explosions lead to the belief that the designers of this class of machinery are not familiar with the pressures which may be developed by the explosive combustion of gasoline and air under favorable conditions, and consequently are making engines too light to withstand the pressures sometimes found.

The accompanying illustration shows a pressure-time diagram of an explosion of gasoline and air mixture under constant-volume conditions. The diagram was taken with a Crosby gas-engine indicator, equipped with a 280-lb. spring, the drum being driven by a descending weight, which closed the electric circuit and fired the charge at the proper time. The spring subsequently tested showed substantial accuracy. The ratio of the mixture was 1 of gasoline to 8¼ of air by weight, the initial pressure being 68 lb. above atmosphere and initial temperature 129 deg. F.



Pressure-time Diagram of Explosion

The final pressure as measured on the original diagram is 645 lb. above atmosphere, an increase of 577 lb. during the fifteenth of a second the combustion lasted. Should this occur in a gas-engine cylinder 6½ in. in diameter, a total pressure of over 21,000 lb. on the piston might result in the wrecking of a light or poorly constructed engine.

That the accompanying diagram is representative rather than abnormal is shown by the fact that three other dia-

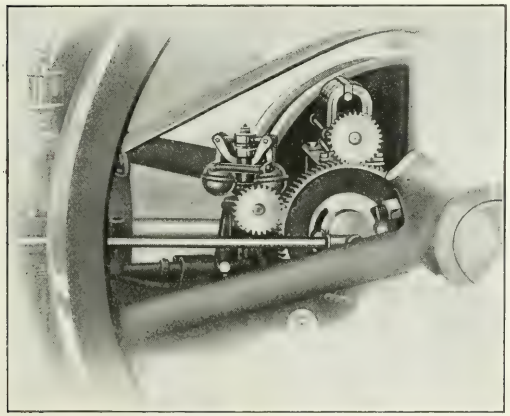


Fig. 1. Mounting of Foos Magneto

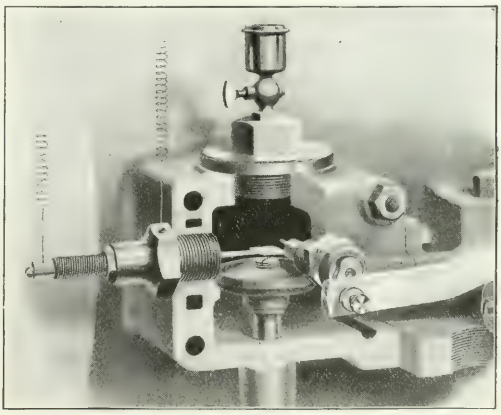


Fig. 2. The Igniter

machine delivers alternating current and is so synchronized with the engine through the gearing that the voltage peaks occur at the proper instants for ignition. No contact breaker is used, and the current is delivered through brushes bearing on smooth steel collector rings.

The igniter is of the make-and-break class with wiper contacts, the moving

grams gave pressure rises of over 500 lb., eight diagrams rises of 475 to 500 lb., and nearly all mixtures tried of whatever ratio gave pressure increases well above 400 lb. That such results are not shown by the ordinary gas-engine indicator diagram is probably due to the fact that in the process of compression in a gas engine the temperature becomes much higher than in the experimental work, where the iron cylinder containing the mixture was heated by a torch. This results in a smaller concentration of the charge and correspondingly lower pressures in the engine cylinder.

Nevertheless, the greater concentration may sometimes be attained in practice, particularly with the engine cold.

LETTERS

An Automatic Engine Stop

The accompanying sketch represents an automatic circuit-breaker I had occasion to rig up on a gas engine driving a deep-well pump that was not fitted with a bypass on the discharge line. There were times when the engine would be forgotten and the pressure would run up dangerously high, and the pump was so placed that it was almost impossible to install a bypass. Although the circuit-breaker may be an old idea, it serves the purpose; the pressure limit never varies a pound.

I dismantled an old pressure gage and attached the tube *B* to the side outlet of a tee in the pipe leading to the tank pressure gage; then pinned the head end of a screw to the toe of the tube and mounted on the other end of the screw a contact disk *D*, backed up by a locknut *N*. Then I mounted a fiber block *F* on the pipe connection at the base of the bourdon tube to provide a support for the stationary contact *C*, which consists of a screw set in the fiber and a nut to jam the screw where it is set and to hold the end of a wire leading to a cutout solenoid. The screw carrying the disk *D* passes through a hole in the fiber with ample clearance. On the end of the solenoid plunger I mounted a contact blade *J*, fitted to enter the spring clips *K*, which are insulated from each other.

Following the connections will show that the screw *C* and disk *D* control the circuit to one terminal of the solenoid winding and the blade *J* and clips *K* control the circuit to the igniter and the other solenoid terminal. Normally, the disk *D* is not in contact with the screw *C*, but the blade *J* is between the clips *K*, being set there by hand. The terminal *I* is connected to the insulated electrode of the igniter and the terminal *G* to the uninsulated electrode in order to prevent a short-circuit through the path between the pressure tank and the engine frame.

When the pressure rises to a set point, the bourdon tube draws the contact disk against the screw *C*, closing the battery circuit to the solenoid, which pulls the blade *J* out of the clips, opening the ignition circuit and the circuit to the solenoid winding at the same time. The reason for having the solenoid circuit broken at the same time is that the contact points *C* and *D* do not open until some time after the pump stops, and there would be a useless drain on the battery during that period.

N. E. WOOLMAN.

Danbury, Iowa.

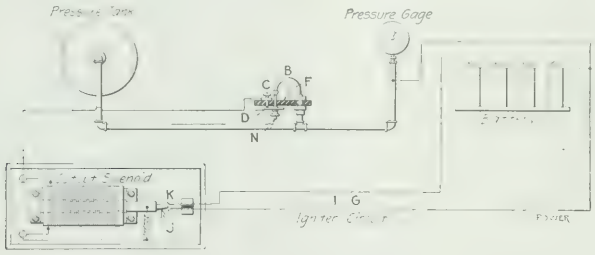


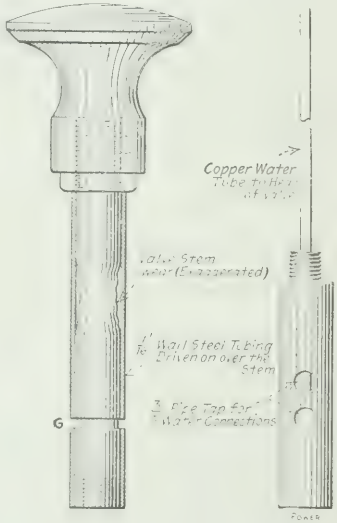
DIAGRAM OF CONNECTIONS TO CIRCUIT-BREAKER

Repairing and Improving Exhaust Valve Stems

When I took charge of the plant here, the exhaust-valve stems of our vertical producer-gas engines were badly worn where they pass through the packing glands, and they were also loose in the guide bushings, making considerable racket when opening and closing. To correct these conditions I made new valve stems of steel tubing of the same inside and outside diameter as the old stems, threading the ends of the new stems to fit the holes in the old heads and securing the union by means of a jam nut and a pin, as shown in the drawing. In the lower end of each valve stem I cut an internal thread to receive an extension piece in which a copper water tube is fastened and to which the water connections are made; this extension piece is shown alongside the valve stem. Then I cut a groove, *G*, near the end of the stem to take a split collar for taking the thrust of the valve spring. This gave me new valves at considerably less cost than buying them.

Now, when a stem becomes worn from the action of the sulphur in the gas and bad water, I take off the extension piece of the stem, turn the stem from the jam nut down to the end and drive on a piece of thin, hard steel tubing of the right length, as indicated in the drawing, which makes the stem of the same diameter as before; then I cut through to the split-collar groove, in the stem, put back the extension water-connection piece, and I have a good stem again. When the tubing becomes worn, I split it off and drive on another piece, and while I have the valve in the lathe I usually reface the disk true with the stem.

Another practice I have adopted to lengthen the life of the stems is to make



REPAIRED EXHAUST-VALVE STEM

new water-connection extension pieces long enough to reach into the lower guide bushings, cut off the push rods and take off the caps over the ends of the push rods that held the adjusting liners; the liners are put in the lower guide bushing, between the end of the valve stem and the push rod. This prevents the lower end of the stem from jumping around when the packing wears, and keeps the stem in line with the axis of the seat.

I have also arranged the water connection to the exhaust valve to take warm water from the jackets instead of using cold water, thereby preventing sweating and considerable wear. The guide bushings for the exhaust-valve stems were also found to be worn, so they were bored out ⅛ in. larger and babbitted to the proper size; they are still in use. I use a mixture of grease and graphite for lubricating the stems, with forced feed.

J. W. FRIES.

Middleboro, Mass.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Vacuo Hot Water Heating*

By Ira N. Evans

Much of the material in the first part of this paper has been previously covered in Power in the series of articles on hot-water heating and may therefore be passed over to the latter part of the paper which deals with a steam-turbine plant under variable load supplying steam to the heating system. A similar problem with the turbine under constant load has been considered in the series of articles just referred to. See p. 419, Sept. 12, 1911.

For a variable load, such as is considered in this paper, a chart should be worked out for the heating in pounds of steam, and one for the daily load, showing the average hourly variations for 24 hr. With pounds of steam as ordinates and hours as abscissas, the curves of steam consumption for each 5 in. of vacuum between full vacuum and atmosphere should be plotted for the engine or turbine for the average daily load, showing the hourly variations. From these charts another should be constructed for each 10-deg. period from 0 to 60 deg. with pounds of steam as ordinates and hours as abscissas. Each chart will have four curves: the typical curve of temperature outside, showing the hourly variation; the turbine steam consumption at full vacuum; the heating curve in pounds of steam, and the curve of actual steam consumption of the turbine at the hourly loads.

*Excerpt from paper read before the American Society of Heating and Ventilating Engineers, New York City, Jan. 25, 1912.

By dividing the hours, Table 2, by 24, the number of days can be obtained for each 10-deg. period of temperature. When the areas between the curves on each of the six charts are determined and multiplied by the number of days in each case, the heating, excess steam and cost of reducing vacuum can be determined for the season.

Heating and power curves together with the steam consumption are worked out in Figs. 1 to 8, and Tables 1, 2 and 3 for the entire heating season with the variable power load as it actually occurred.

Fig. 3 gives the operation of a hot-water system for weather 0 to 10 deg. outside. It also gives the typical conditions of operation as they would occur on a vacuum system of steam heating. The hatched spaces would show the steam wasted to the atmosphere through the relief valve. As the heating system cannot be operated with steam much below 212 deg., the curve *H* would give the steam requirements on a vacuum system without allowances for condensation losses. This condition would be nearly constant throughout the entire heating season.

If the load on the plant was such as to supply only exhaust steam enough to balance the heating from 5 p.m. to 8 a.m., allowing no exhaust steam to escape to the atmosphere at those periods, live steam would have to be used from 8 a.m. to 4 p.m. This is generally the period of highest temperatures during the day and highest water temperature for heating. A slight decrease in vacuum

TABLE 1 HEAT DEMAND AND SUPPLY, HOBOKEN TERMINAL, LACKAWANNA RAILROAD

Outside Temperature, Degrees F.		*S* Supply Therm., Deg. F.	*R* Return Therm., Deg. F.	*D* Dif. Temp., Deg. F.	*V* Max. Vac.	*L* Latent Heat, B.t.u.	*H* Lb. Steam per Hour, $\frac{1,158,700 \times D}{L}$	400 Kw. *T* Rate	*T* Lb. Steam, 400 Kw. Load	*T*—*T'* Cost operated Red. Vac., Lb. Steam	*T*—*H* Surplus Steam, Lb.
1	0– 5	211 1	197	14.1	3 lb.	960	17,020	47	18,800	10,560	1780
2	5–10	206	192 6	13.4	0	966	16,073	43	17,200	8,960	1127
3	10–15	200	187.3	12.7	3″	969	15,187	41	16,400	8,160	1213
4	15–20	194 5	182.5	12	6.4″	973	14,292	38 8	15,520	7,280	1228
5	20–25	188 3	177–	11.3	9″	977	13,402	37	14,800	6,560	1398
6	25–30	181 6	171–	10.6	11.5″	981	12,520	35 2	14,080	5,840	1560
7	30–35	174 9	165	9.9	14″	986	11,654	33 5	13,400	5,160	1746
8	35–40	167 8	158 5	9.3	17″	993	10,853	31 4	12,560	4,320	1707
9	40–45	158.5	150	8.5	19.5″	1000	9,851	29 5	11,800	3,560	1949
10	45–50	146 6	139	7.6	22″	1007	8,745	27 3	10,920	2,680	2175
11	50–55	133	126.5	6.5	24.2″	1016	7,412	25 2	10,080	1,840	2668
12	55–60	117 5	112	5 5	26 2″	1027	6,205	23	9,200	960	2995
13					2 ″			20 6	8,240		

1,158,700 lb. water circulated per hour. Old values used before Marks and Davis tables were adopted.

TABLE 2. NUMBER OF HOURS FOR EACH 10 DEG. PERIOD OF TEMPERATURE FROM 0 TO 60 DEG., NEW YORK DISTRICT

Month	Week Days "A" Days 7 a.m. to 5 p.m. 0°-10°	10°-20°	20°-30°	30°-40°	40°-50°	50°-60°	Week Days "B" Nights. 5 p.m. to 7 a.m. 0°-10°	10°-20°	20°-30°	30°-40°	40°-50°	50°-60°	Holidays, Sundays "C" Days 7 a.m. to 5 p.m. 0°-10°	10°-20°	20°-30°	30°-40°	40°-50°	50°-60°	Holidays, Sundays "D" Nights. 5 p.m. to 7 a.m. 0°-10°	10°-20°	20°-30°	30°-40°	40°-50°	50°-60°
Oct.				5	35	85					56	140					10	30				28	21	63
Nov.				90	105	20				168	105	14				35	45					119	14	
Dec		25	100	80	20			70	175	28	14			15	45	10	15			56	70	14		
Jan		10	60	135	25		28	14	84	161	14			5	25	35	15			7	10	56		
Feb.	10	15	40	95	35	15	14	28	70	105	28	21		5	40	25			14	14	84		14	
Mar.			5	90	90	55			21	168	84	49				5	35	15					42	70
April.				5	35	155				14	133	154					10	40					70	42
May					5	100					28	154						25					28	28
Total	10	50	205	500	350	430	42	112	350	644	462	532		25	110	110	130	110	14	77	161	217	189	2038
Per cent.	0.19	0 99	1 07	9 94	6 95	8 54	0 83	2.23	6 95	12 8	9.2	10 6		0 5	2.19	2.19	2.58	2.19	0 27	1 53	3 26	4 3	3 76	4 04
Total	1545 hr. 30.68 per cent.						2142 hr. 42.6 per cent.						485 hr. 9.65 per cent.						864 hr. 17.16 per cent.					
													3491 hr. 69.32 per cent.											

at these periods of light load on the vacuo-water system eliminates the use of live steam at that time.

If the plant were arranged for a vacuum system requiring steam as per Fig. 3, curve *H*, there would be no saving in operating the plant condensing, as the steam would be required for heating at all times.

On the other hand, if the engines were operated noncondensing, according to curve *T*, Fig. 3, there would be no saving in operating a hot-water plant, as the steam consumption would be required for power regardless of the heating system. There would be a saving with the hot-water system if the power was insufficient to balance the heating and during periods of live-steam operation when the engines were shut down.

By placing a vacuum on the engines the full capacity of the heating system as a condenser is obtained for practically no expense and as the heating and power load reach a balance the amount of exhaust steam is reduced and the steam consumption of the heating system is lessened at the same time. When the power load on the unit is not reduced to the balanced quantity or the excess steam spaces not taken care of by the condenser, the water in the heating system becomes heated very quickly and the condensing effect destroyed. This is where the saving on the combination is effected.

In cases where no condenser is available the power load on the engine can be reduced by regulating the vacuum and water temperature and producing the same result. The power not needed for heating should be turned out doors. In this manner a lower rate per kilowatt-hour would be obtained for the engine operated on the heating system than the units exhausted to the atmosphere.

By this arrangement there is no reason why all hot-water heating plants should not be operated under vacuum on the portion used for exhaust-steam heating. It is simply a question whether the remainder of the power load is sufficient in quantity to warrant a condensing outfit.

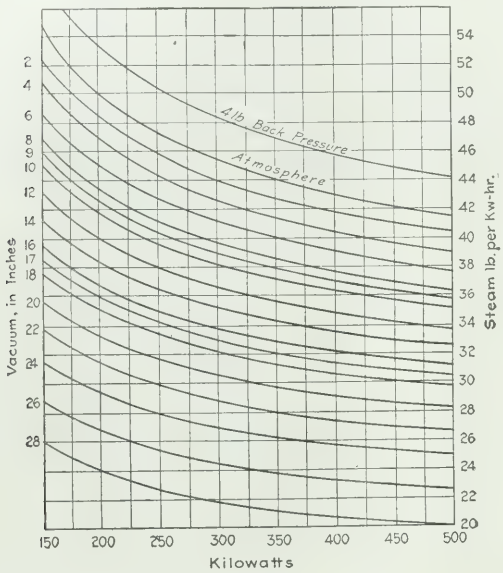


FIG. 1

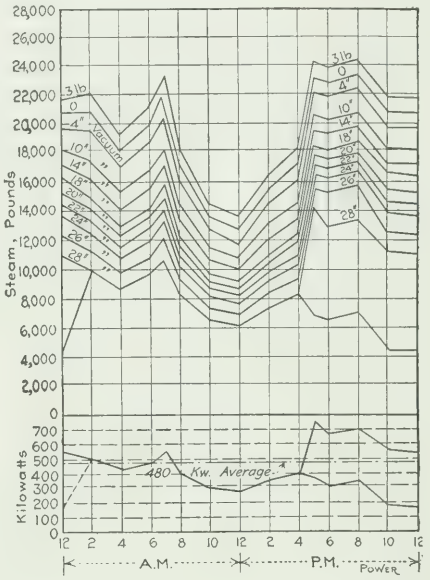


FIG. 2

By dividing the total steam for power and heating, Table 3, or 68,870,482 lb., by 209.79 days, the average daily load for power and heating will be found to be 328,000 lb. per day. This shows that Figs. 6 and 7 will give the average condition on a hot-water system that would require the same steam and operating conditions as a vacuum system at 0 to 10 deg., as in Fig. 3. These charts show a vacuum of from 18 to 20 in.

The average heating ordinate for Figs. 6 and 7 from Table 3 is about 10,000 lb. per hour against 15,000 lb. for Fig. 3. This means that if the power was only sufficient to furnish 10,000 lb. of steam a vacuum could be carried all the time and the heating accomplished with hot

TABLE 3. DATA OBTAINED FROM PAGES 1 TO 8

Outside Temperature, Degrees F.	Days	Curve *H* Heating per Day, Lb. Steam	Total Steam Heating, Lb.	Curve *T* Steam Power and Heat per Day, Lb.	Total Steam Heat and Power, Lb.	*T*—(*H* or *T'*) Excess Steam, Lb.	Total Excess Steam, Lb.	Average Ordinates: Power and Heating, Lb. Steam	Heating, Lb. Steam	Excess, Lb. Steam	Steam, Rate per Kw.-hr.
0–10	2.75	374,500	1,029,875	440,000	1,210,000	65,600	180,400	18,333	15,604	2733	38.2
10–20	11–	353,600	3,889,600	428,800	4,766,800	75,200	827,200	17,856	14,733	3133	37.2
20–30	34.5	314,240	10,841,280	385,600	13,303,200	69,120	2,384,640	16,070	13,100	2900	33.5
30–40	61.3	277,440	16,820,720	348,800	21,381,440	74,400	4,560,720	14,533	11,433	3100	30.3
40–50	47.12	224,640	10,585,040	307,520	14,490,342	63,200	2,977,984	12,813	9,360	2633	26.7
50–60	53.12	157,120	8,346,214	259,200	13,768,700	27,840	147,886	10,800	6,550	1160	22.7
Totals.....	209.79	.....	51,512,729	.....	68,870,482		11,078,830				

Average power, 480 kw.
228,800 lb. per 24 hours. Curve *T*.
20 lb. per kw.-hr.@28-in. vacuum

For 209.79 days × 480 kw. × 24 = 2,416,800 kw.-hr.

$$\frac{68,870,482}{2,416,800} = 28.5 \text{ lb. per kw. average rate}$$

water with a very small amount of live steam. If a vacuum system were used under the same conditions 5000 lb. of live steam would be required nearly for 100 days, or 50 per cent. of the heating season.

This shows the importance of balancing the heating and power load and the fallacy of making an uneconomical power plant on a noncondensing basis simply to furnish exhaust steam for a vacuum system. The heating system should in no way influence the question whether a plant should be operated condensing or noncondensing.

Column *H* in Table 1 gives heating requirements in pounds of steam per hour for each condition of outside temperature with the maximum vacuum necessary to produce the water temperatures and maintain a constant temperature of 70 deg. in the room with the proportion of heating surface installed in this particular case. These records are plotted from recording thermometer charts covering a considerable period of time.

Fig. 1 is the steam consumption of a 500-kw. turbine unit under different loads and degrees of vacuum with steam at 150 lb. gage and 15 deg. superheat.

Fig. 2 is the steam consumption for the hourly load under different degrees of vacuum. The load varies from 200 kw. to 750 kw. with two peaks, one at 5 p.m. and one at 7 a.m. The water from the condenser was weighed and the load and the vacuum noted. These variations in load are handled entirely with two machines, and if the load was considerably increased, the charts show that the steam consumption due to the higher vacuum would be very little greater as the machines are underloaded a portion of the time. The hourly load is plotted in kilowatts at the bottom of Fig. 2 and the average hourly load is 480 kw. per hour. All areas were measured by a planimeter.

The double power curves show when two machines are operated at the peak, one under reduced vacuum for heating and one at 28 in. vacuum. The load one machine will carry at no vacuum is 375 kw., and 950 kw. has been carried a short time at 28 in. vacuum with one machine. A load of 375 kw. just balances the heating load in amount of steam and temperature by simply changing the vacuum.

Up to 30 to 40 deg. outside, Fig. 6, it is most economical to operate two machines from 4 p.m. to 2 a.m., but for Figs. 3 and 8 it is necessary only to operate two machines from 4 p.m. to 10 p.m. Except in extreme weather at low vacuums, the load is carried at all times with one machine or until the vacuum gets below 10 in. In working out the charts the minimum steam consumption will be shown by operating the two machines as indicated.

Curve *T'* is the steam consumption of the turbine under the characteristic load at 28 in. of vacuum. Curve *H* is the curve of heating corresponding to the curve of outside temperature at the bottom of each chart for a typical day for each period of 10 deg. range of outside temperature. Curve *T* gives the steam consumption of the turbine under the hourly load and vacuum which will produce the proper water temperature for curve *H*.

At the peaks the vacuum has been decreased slightly so as to improve the steam consumption. From curve *T'* at 28 in. of vacuum the area to the base line represents the steam consumption required for power if no heating were required. Curve *H* likewise incloses the area for the hot-water system, whether live steam or exhaust is used. Curve *T* gives the requirements for heating and power combined for each typical day and power load. The saving is the excess steam areas between *T* and *H* or *T'*, as the case may be deducted from the area inclosed by *T'*. All areas were read by a planimeter, and the average ordinates and results are tabulated in Table 3 and graphically in Fig. 1. It may be seen that in most cases *H* is greater than *T'*, but for the high temperatures out of doors, *T'* is frequently greater than *H*. In any case, the heating and power at full vacuum are fixed by requirements regardless of other conditions.

When less power is generated than the balanced load, the vacuum will have to be reduced, to increase the quantity of steam to maintain a proper water temperature on the heating system. It will not pay to carry normal vacuum for that outside temperature and operate the live-steam heater to furnish the additional heat, although the apparatus is arranged so that this could be done.

At noon in most cases, the vacuum is reduced below normal to furnish steam for heating on account of light load. Where this occurs on a vacuum system, the reducing valve would have to be opened to supply live steam to keep the pressure from dropping too low. The curves show that this arrangement would be ideal from an operating standpoint for a high office building and hotels where the heating load at times exceeds the power load. One turbine unit could be operated on the heating of a size to just balance the requirements of the heating system, and when the machine is underloaded the decreased vacuum would be no additional expense.

When the turbine load can be balanced against the heating, the excess steam on the charts will disappear. In this case 375 kw. just balances the heating at all outside temperatures. This would also eliminate the different-sized units to take care of the variations in

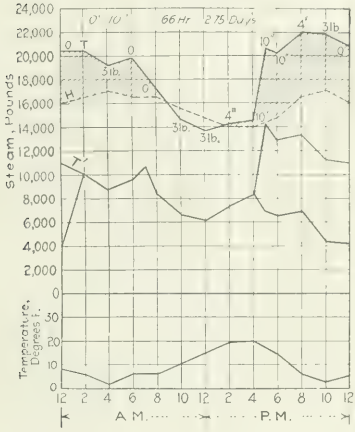


FIG. 3

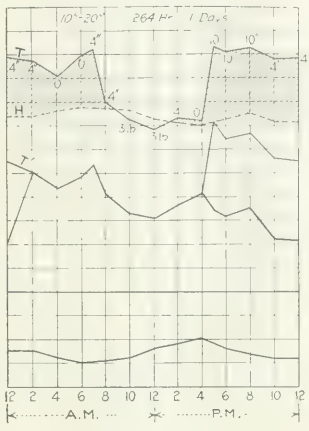


FIG. 4

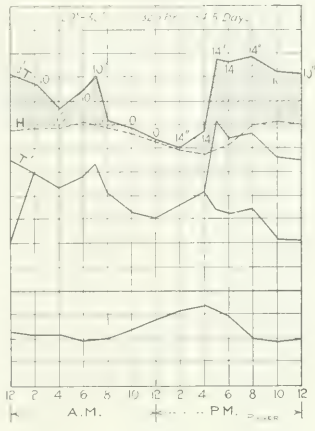


FIG. 5

load so as to obtain an economical steam consumption as in the case of reciprocating engines.

As the summer load is considerably less than the winter load, condenser capacity need be furnished to the extent only of the power installed in addition to that which will balance the heating, utilizing the vacuum that this condensing capacity will produce in summer under the reduced conditions of load. This will cut down the first cost of installation without seriously interfering with the economy. It is a question to be determined in each particular case. The only reason advanced for not operating condensing engines for large office buildings has been the requirements of the vacuum-heating system or possibly the excess of heating over power requirements. With the hot-water system as described, more than 20 in. of vacuum can be carried 80 per cent. of the time, and the heating provided for with exhaust at the same time. It will also be noted that the maximum daily temperature occurs at the time of the peak load in the New York district, which means a greater vacuum.

The operation of the plant is simple, the temperature of the return water being regulated by adjusting a single valve at intervals of two hours as the load or outside temperature changes. The curves and resulting vacuums are entirely the result of manipulating this one valve, and the hourly load at that period. The second turbine is started when necessary and the same condenser handles both machines, one exhausting direct to the condenser under full vacuum and the other to the hot-water system under reduced vacuum. Attention is called to the following facts demonstrated by Table 3 and the charts:

The heating curves show 100 per cent. range between the 0- to 10-deg. condition and the 50- to 60-deg. condition. This range is impossible on a steam system except with automatic heat control kept in operating order. If the 0- to 10-deg. condition, and 374,500 lb. of steam per day are taken for the steam consumption minimum for a vacuum system at 212 deg., the total steam consumption for 209.79 days would be 78,566,000 lb. against 51,512,729 lb., or a difference in favor of the hot water of 27,043,271 lb., which at 20c. per 1000 lb. would be a saving of $5410 per year, or 35.4 per cent. saving. This shows the saving in favor of hot water, where there is no power to be considered and live steam is utilized for heating in either case.

If 45 lb. per kilowatt-hour at the switchboard is taken for the steam consumption of the engine at atmosphere, the steam used during 209.79 days for 480 kw. average load would amount to 108,756,000 lb., which, at 20c. per 1000 lb., would cost $21,751. This does not allow for any live steam for periods of low load to keep up pressure on the heating system and preventing air leaks.

The cost of power and heating combined on the hot-water system is (68,870,482 lb. at 20c.) $13,774. This represents a saving of $7977, or 37 per cent.

The cost of operating the hot-water system on live steam and condensing the engines under full vacuum would be

51,512,730 + 48,000,000 = 99,512,730 *lb.*

which at 20c. amounts to $19,903. Also,

99,512,730 — 68,870,482 = 30,642,248 *lb.*

which at 20c. amounts to $6130 per heating season, or 31 per cent.

The saving effected by utilizing the turbine under partial vacuum may be found by deducting the excess steam from the steam under full vacuum or

48,000,000 — 11,078,830 = 36,921,170 *lb.*

At 20c. this amounts to $7384, or 73 per cent. of the steam at full vacuum.

In case coal at a lower cost than assumed is available, a proper proportion will determine the saving. This saving is figured in fuel at $3.60 per ton and does not include city water saved in condensation or wear and tear on extra boilers and apparatus to burn the fuel.

If properly designed, a hot-water system can be installed for the same cost nearly as a low-pressure steam system if all specialties are included. The covering for risers within the building required on steam can be omitted, reducing the temperature of the water within the system by the amount corresponding. Automatic heat control can be omitted as a constant temperature in the rooms can be maintained by regulating the temperature of the water at the plant. These items of expense will more than balance the cost of the heaters and pumps. In any case, the saving capitalized would warrant a considerable expenditure in addition in favor of the water system. These savings can be taken as nearly standard percentages for any condition.

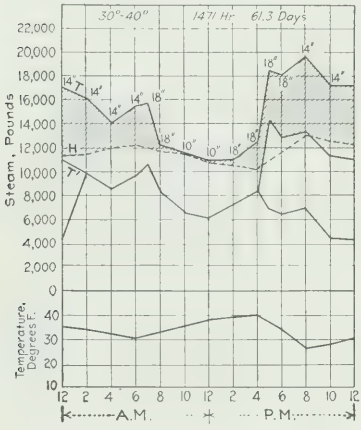


FIG. 6

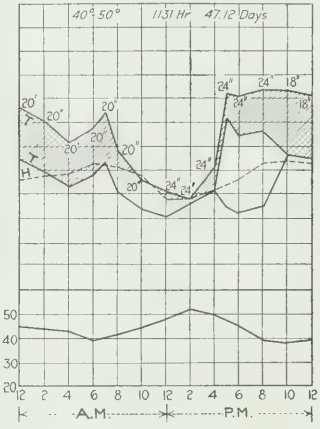


FIG. 7

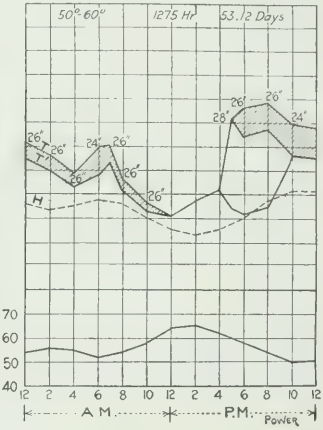


FIG. 8

Recently the Census Bureau at Washington issued a statement relative to works manufacturing locomotives.

There were 16 establishments in 1909 and 15 in 1904; in 1909 the capital invested was $52,060,000, a gain of $13,639,000, or 35 per cent., over $38,421,000 in 1904.

In 1909 the value of the products was $31,582,000, and $59,552,000 in 1904, a decrease of $27,970,000, or 47 per cent. There was added in 1909 by manufacture $16,522,000, and $31,849,000 in 1904, a decrease of $15,327,000, or 48 per cent.

For salaries and wages there were paid $11,211,000 in 1909 and $17,473,000 in 1904, a decrease of $6,262,000, or 36 per cent. The army of wage-earners numbered 14,909 in 1909, but in 1904 there were 28,806, a decrease of 40 per cent.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

The Indicator and the Orsat

A neat way of expressing their appreciation of the efforts of their engineers toward self-improvement and of aiding them to that object without being in any way patronizing, was that adopted by the manufacturers of Fitchburg, Mass., in presenting to the local engineers' association a complete indicator outfit.

There is probably no one thing that has awakened more engineers to a real live interest in the larger side of their calling than this stethoscope of the engine. Its revelations have made the internal workings of the machine so apparent, their study has led them into such pleasurable and profitable paths of study and investigation and shown so directly the bearing of the theories and principles involved upon their everyday work that it has lifted its students out of the humdrum of manual labor and started them out to be real engineers.

But far and away above the worth of the gift to the association is the significance to them of the spirit which prompted its donors. They can and will make the instrument pay big interest upon its cost to the power-plant owners who participated in its presentation; they will esteem and respond to the thoughtfulness and kindly spirit which moved somebody to think of it and the others to approve and aid in carrying out the suggestion.

There is another instrument about which the average engineer knows less than he does about the indicator. It relates to the boiler as the indicator does to the engine. By an analysis of the gases rejected at the uptake it shows how complete has been the process of combustion, how much unnecessary air has been uselessly heated up, what proportion of the heat that was in the coal is going away in the stream of gas which goes to the chimney.

As an engine is made so must it run. The most that one can do is to set its valves properly, keep it packed and lined and lubricated, and accept its results. The boiler is much more flexible. With a given installation one man may make twice as much steam per pound of coal as another. The average efficiency is probably below sixty per cent., while over eighty is attainable and attained. The processes of the boiler room are more interesting than those of the cleaner and more comfortable engine room, and an understanding of those processes and the intelligent application of that understanding promise more than any other direction in which the operating engineer's activities can be exerted.

We suggest that some other group of employers who wish to do a graceful and profitable act should present their associated engineers with a complete apparatus for sampling and analyzing flue gases with the pyrometers, thermometers, etc., necessary to determine its temperature, and furnish them with it a lecturer or instructor who would teach them how to use it and apply its indications.

The resultant interest in the problems of combustion, the ability and inclination to make a heat balance and the striving to make the "heat applied" item as large as possible would pay an enormous interest upon the investment.

Safety Precautions in Electrical Work

The advent of the steam turbine has been a large factor in introducing and promoting the use of electricity for power purposes, with the result that there are today many plants, particularly smaller ones, developing power by means of turbo-generators and then distributing this power to the various points where it is needed. This has naturally done away with the small individual steam drives so common a few years ago, and with which the operators were thoroughly familiar, and has introduced an entirely different phase in power engineering. In many instances where changes of this kind have been made, the old engineers and operators have been retained and are expected to go right along

and handle the new equipment with the same degree of skill as they did the old. To men not very familiar with this form of generation and use of power there is always more or less fear for their personal safety and often life is endangered by their ignorance as to the proper precautions to be observed in protecting themselves.

One frequently hears of electrical workers being killed by the current, and from this naturally proceeds the belief that all electric currents are dangerous and that any contact with a highly charged conductor will result in a serious, if not a fatal, shock. There is, however, considerable misunderstanding on this point. Men in charge of electrical equipment survive their constant attendance upon and care of the most dangerous machines in regular operation by simply observing certain precautions and following fixed rules so that practically all danger is removed. While it is true that it is the characteristic of pressure or voltage in an electric current that makes it dangerous, and also that this pressure must be present in order to distribute the current economically, yet it must also be remembered that such a current is harmful only if allowed to pass through the body, and in order to do this it must have a means of exit as well as one of entrance. Care must be exercised, therefore, to prevent such a possibility.

For this reason there should always be provided a dry wooden or rubber-covered platform or floor about a high-tension generator so as to give good insulation and a similar precaution should also be made in front of the switchboard. A man standing upon such a floor, provided it and his shoes are perfectly dry, cannot possibly be injured by the most vicious current should he simply touch one of the wires conveying it because his connection with any return conductor would be lacking. Dry shoes afford, in themselves, some measure of protection, as they are of an insulating material, but if they are damp or contain nails, a ready path to ground will be given to the current with possibly fatal results. When working upon or about high-tension machinery or wires, many electricians make it a rule to use one hand only, keeping the other away from the work entirely. In all cases, gloves and rubber overshoes which at least tend to protection.

Safety also demands that all wires be amply protected to prevent contact with them and also railings about the machinery and legible signs conspicuously located so that they will always be a warning. Carelessness and contempt through familiarity with electrical equipment of a dangerous nature are probably the chief causes for a majority of accidents.

The Engineers' Diary

The engineers' diary or log book fills an important place in the daily operation of the power plant. Items of interest and value for the preserving of which there is no other provision may be recorded here. In addition to the usual information given in the log or the daily data sheets, there are many items which may well be recorded, as memoranda of supplies needed, of repairs which are necessary or soon to be necessary; reports of inspections of equipment; the history of belts, packings, valves and the minor paraphernalia of the plant; observations on the performance of lubricants, chemicals for treating feed water, heat insulators and other materials; lists of materials received and used. These items are merely suggestions; the desirability of recording many others will be apparent.

The conclusions arrived at as the result of tests of the plant or equipment should also be entered here, with the changes which were suggested thereby, and summaries of the important tests should be included for convenience in making comparisons. If experiments are conducted the results should be recorded for future reference. While this information is filed in detail with the plant records, it is often not readily accessible or easily consulted. The diary will serve as a clearing house for betterment ideas.

In the event of an unusual occurrence or accident, the report of the engineer as made at the moment will furnish valuable evidence and serve as an efficient prompter to his memory should the necessity arise. The proper place for the original draft of this report would be in this diary.

It may seem that much of the information recorded has slight value when the matters often assume unlooked-for importance after an interval of time. Such a record should be neatly and durably bound and fully indexed.

Some English physicians are recommending the smoky parts of Sheffield, England, for sufferers from asthma. Is this a rebuke for the smoke-abatement movement, or merely an asthmatic wheeze?

The high cost of living will doubtless be lowered in time, but the man who neglects to acquire a thorough working knowledge of his vocation will always find it hard to pay his way.

Only one flywheel explosion is listed for the United States and Canada for last November, says *Engineering News*. Was this luck, or increased care?

That over 3000 steam engineers have been graduated by one reputable correspondence school is a convincing argument of the practicability of this kind of education.

How much exhaust steam does your manager sell to nearby shops and buildings? If he does not know it is feasible, and you do, why not suggest it?

The scientists tell us that there is "a vacant space in the human head." It might be utilized as a mental repair shop if some of us were awake to our poor operating condition.

Owe no man anything but good will. If you get a helpful kink out of POWER this week, pay your indebtedness by "kinking" him back.

Now and then, POWER is asked to recommend a first-class operating engineer. Are your name and qualifications included in its list?

At a recent banquet at Cincinnati, Ohio, Mayor Baker asserted that within two years the city will own electric plants which will furnish current at, if not under, 3 cents per kilowatt-hour.

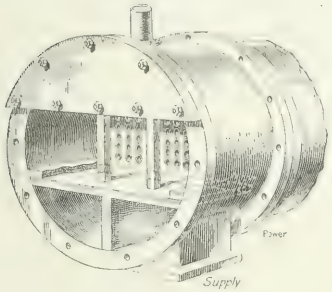
This is the season for starting up the

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Plank Baffle Plate

One day the vacuum dropped from 26 to 10 in. The apparatus was looked over carefully but the cause could not be found, so the engines were kept running at the lower vacuum until the following Sunday morning; we were obliged to



WOODEN BAFFLE PLATE

have them in operation again at 6 o'clock that night.

The lower part of the surface condenser head was removed and the baffle or division plate was found broken in several pieces. The chief suggested putting in a 2-in. plank; this was done, as shown in the illustration. Although this job was done three years ago, the plank is as sound as ever, and the condenser maintains between 26 and 27 in. of vacuum.

R. A. HAFFORD.

Groveton, N. H.

Wrong Receiver Piping

In a certain central station all of the condensers were located in the boiler room next to the dividing wall between the engine and boiler rooms, and it was a part of the water tender's duties to watch the condensers.

One of the units consisted of a 14 and 28 by 36-in. tandem-compound Corliss engine connected to a single-jet condenser; the top of the condenser cone was about 18 in. below the bottom of the low-pressure cylinder. There was a 1½-in. pipe from the city water main connected to the cone that was used to prime it when necessary. One day this unit was cut out in order to do a little work on it, and the attendants were standing by waiting for it to stop; they stated the engine would not have made two more revolutions, when it was wrecked by knocking out the front of the main bearing, breaking the cap and springing the shaft at the crank disk.

On investigation it was found that the 1½-in. priming valve was wide open. The receiver was set about 4 ft. to one side and under the floor in a trench dug in the ground and about 1 ft. above the bottom of the trench, as shown in the sketch. It was about 24 in. in diameter with a manhole in each end. About 18 in. from each end there was a tube sheet with four 4-in. tubes rolled in, the bottom tubes being about 5 in. from the bottom of the shell. There was a live-steam connection in the space between the tube sheets which was used as a reheater; this space also had a drain connected.

The end into which the high-pressure cylinder exhausted was drained; the other end of the receiver connecting to the low-pressure cylinder was also fitted with a drain connection, which was plugged, although that end was about 4 in. lower than the other.

One night, about three years after the first accident, in picking up this unit, when it got to about half speed, it knocked out the main bearing and broke the cap as before. When both manheads of the receiver were taken out it was found that the end next to the low-pressure cylinder was filled with water up to the bottom tubes.

That, it is supposed, is where it got its dose of water; anyway, that drain was then connected. This was negligence and carelessness in installing and operating.

L. W. RAGSDALE.

Beverly, Wash.

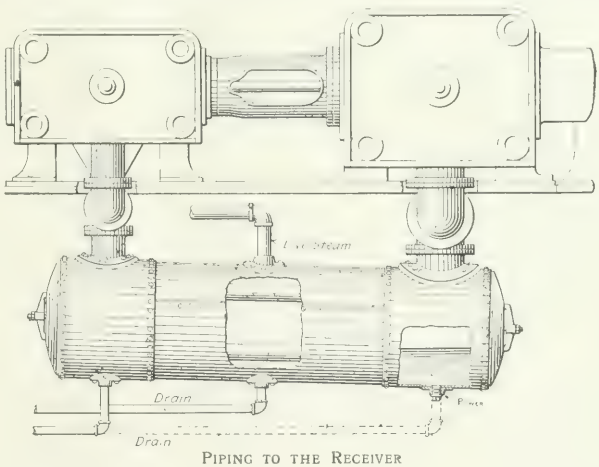
Mistakes and Carelessness

It is a mistake to remove all of the nuts from the flange-bolts when breaking a joint, on the assumption that there is no pressure on the steam pipe. A little more time may be taken in doing the work if the nuts are first slackened back a thread or two; the joint is then started, and if no pressure is on the part it can be opened up; if there is pressure, a turn of the nuts makes matters all right until the steam can be turned off.

Not long ago I saw an act that might have resulted in a serious accident. Several men started to overhaul a large reducing valve. The nuts had been removed from the mudhole-door bolts, the wedges were driven in, and the door joint broken, with the result that the men received a warm bath.

It is a mistake to tighten up the nuts on a joint under pressure when there are only three screws to the joint, as one of the screws may be in a dangerous condition. Not long ago a man was scalded to death through the breaking of a screw in an economizer cleaning-door joint; he was tightening it up while the economizer was working. He used an excessively long spanner and broke one bolt; the other bolt gave way under pressure, there being only two bolts to the joint. Men have been killed while tightening up the tube-caps on water-tube boilers while the boiler was under pressure.

It is also a mistake to open the bypass



PIPING TO THE RECEIVER

of a steam trap draining a live-steam pipe through which there is no circulation of steam if there are indications that the trap is not working; the main stop valve should first be closed.

Once, after hours, I noticed that the steam trap draining the fire-pump steam pipe had water trickling from the gland. The pump was not working at the time, and, without thinking, I opened the by-pass. Water-hammer started, and before I could get out of the pump house to shut off the steam the pump valve burst.

All know of the grave danger of doing these and many other things, but we are apt to get very careless. I knew an Italian electrician who would not go near any electrical apparatus without having one hand in his pocket. He said one should never shake hands without a proper introduction, and that this applied especially to electrical apparatus.

WILLIAM GILLEAN.

Barna, Scotland.

Saving Clerical Work in Station Reports

Keeping records is the bane of many an engineer's existence. Hundreds of able power-plant operators would rather pack a drip valve near the bottom of a dirty, ill-lighted sump than to fill out half a dozen lines of a report blank after making an emergency repair, and they are not to be blamed for disliking the "old man's" red tape. But records of plant work and operation are now as much a part of the business as engine and pump surgery, and the wise engineer faces the facts instead of grumbling and puts some hard thinking into the problem of doing the clerical work as easily as possible.

Much depends upon the form of log employed and the extent to which graphic methods are utilized. Sooner or later in every plant the routine conditions become so well established that most of the events can be classified, even if they cannot be foreseen. Take the single point of service interruptions. These may come very infrequently in a well managed steam plant, or they may occur oftener than one would suspect on a large system having a number of hydro-electric stations feeding a common transmission network. The whole system may seldom be interrupted, but for legitimate or accidental reasons some part of it may frequently be temporarily out of service.

Now, the causes of such interruptions have been classified on one representative system of this kind according to letters of the alphabet, a key being placed on the daily report sheet of each station, and when any portion of the system is [illegible] only, necessary for the operator to insert the proper letter at the time of the occurrence. Thus, "A" signifies "automatic switch tripped"; "E" means "service switches held out stated time at request of consumer"; "H" indicates that there was "interruption for line work, arranged for by load dispatcher"; "J" indicates "low voltage and poor regulation," etc., there being 16 ordinary causes of trouble. This plan is so simple that it is surprising that it is not more generally used, along with other abbreviations for repairs and adjustments of individual pieces of apparatus.

Another labor-saving scheme is the plan of leaving out most of the vowels in making notes on the log. A little practice soon enables the engineer to describe events of more or less importance in surprisingly little space. Thus, "Rpd + tml auto circbkr sgnl cntct" tells just as much of a story as the long-hand sentence, "Repaired positive terminal of automatic circuit-breaker signal contact." There is a chance to take a leaf from the record book of the train dispatcher along the lines of brevity without incompleteness in improving the records of power-plant operation.

Plotting the load variations and important meter readings on a station log sheet instead of tabulating them also saves time and labor. A simple check mark on a properly calibrated cross-section scale is all that is necessary in many cases. Where the reading is fractional with respect to the scale, it may be desirable to write the figure against the check, but usually the check mark is sufficient. Recording wattmeter readings of total output of any particular service may properly be put down in figures, but there are many entries on the average station log sheet which can be plotted graphically without the slightest injury to anybody

Another place where time can be saved is in the use of constants for a given installation of equipment. The displacement of a pump should be figured once for all, and similarly, the constant quantities imposed by an engine of given size and type upon the equation by which the indicated horsepower is calculated should be determined once and filed in an accessible place rather than refigured at every occasion. Instead of writing in figures the times of starting and stopping service from different prime movers and auxiliaries, numerous plants are now utilizing the simple and effective scheme of drawing a horizontal line past the hours of operation and breaking it at shutdowns, on the same scale as the load curve.

There are many ways in which the engineer can save himself trouble without interfering with the accuracy or completeness of his records, and each plant presents a little different combination of equipment and service conditions from which the proper abbreviations may be selected.

H. S. KNOWLTON.

Newton, Mass.

Valve Locking Devices

Many accidents are due to the stop valve on an empty boiler in a battery being left open when a man was inside. By using the simple arrangement shown herewith this accident could not occur. Safety valves and doors are locked, and dangerous valves should be locked also.

In Fig. 1 *B* is a strap having a swinging arm *C*. When it is desired to prevent the valve from being opened or closed it is locked as shown. When the arm *C* is not in use it will hang down out of the way. For large valves it is good practice to make an iron arm, using it as shown in Fig. 2. The part *E* is made wide enough to prevent its being turned between the spaces in the valve handle. These suggestions are for simple locks only.

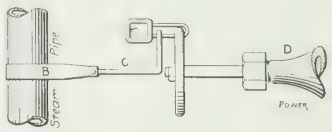


FIG. 1. LOCK FOR VALVE WHEEL

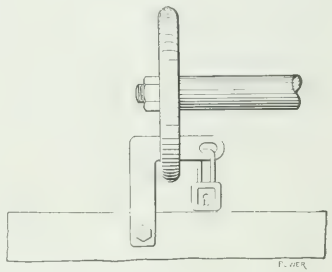


FIG. 2. LOCK FOR LARGE VALVES

JOHN THORN.

Toronto, Can.

Water in Ashpit

Reading a recent article on putting water in the ashpits recalls experiences with using screenings or washings from the culm piles in a large station with boilers having two 10x10-ft. grates each, and about an inch of forced draft in the ashpits. The boilers were hand-fired and had six doors to each grate.

When the fires were cleaned the thin layer of good fire was pushed to the back and the entire front half of the fire was burned down and dumped. The top of the back half of the fire was spread over the front grate and covered heavily, so that one would think there was no fire there at all. The draft was then put on and the back half, the remaining old fire, was burned down and

dumped. The clean front fire was then evenly spread over the grates and covered as before.

One fireman, in a hurry to get the fires cleaned as fast as the peak load dropped off, would turn the water into the ashpit before the new fire had had a good start and the steam, blowing through the fire from the ashpit, would completely deaden the fire in large spots.

This rather upholds the theory that water in the ashpit chills the fire, but it is no doubt necessary to wet the ashes in the hoppers to prevent burning them up.

As this coal was very fine and dusty, some of it would fall through the grates and collect in the bottom of the hopper and when the water was put on, the water-gas would burn out of the bottom of the hoppers, and sometimes ignite with quite a loud report.

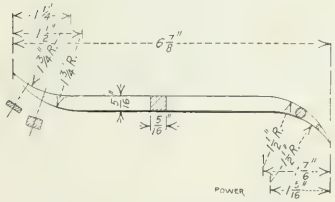
WEBSTER TALLMADGE.

Warren, R. I.

Cotter Pin Extractor

The accompanying illustration shows the shape and details of a tool used for extracting cotter pins. The pointed end of the tool is used for pulling out the pins, and the chisel-shaped end is for spreading the ends of new cotter pins after they have been put in place.

The tool is made from $\frac{5}{16}$-in. square



TOOL FOR EXTRACTING COTTER PINS

tool steel, the ends being heated in a forge, hammered into shape, tempered and then smoothed up on an emery wheel.

To properly shape the tool, first lay it out, full size, on a piece of thin tin, which can then be cut out along the boundary lines and used as a template by which to bend the piece of steel.

H. M. NICHOLS.

Kenyon, R. I.

Clearing a Clogged Blowoff Pipe

After taking down a clogged boiler-blowoff pipe several times and finding the vertical pipe clogged, I thought of another way of freeing it of its accumulation.

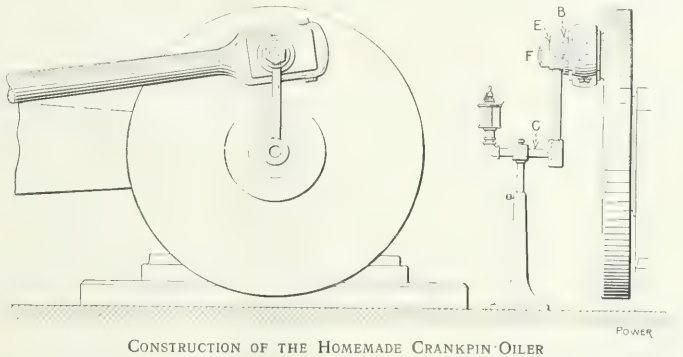
I opened the blowoff valve, put a short nipple with an elbow turned up to be used as a funnel, poured a little kerosene oil in the pipe, closed the valve and started a fire under the boiler. After firing the boiler for about five hours, I opened the valve and it blew out as freely as if it had never been clogged.

AMOS A. AMSTUTZ.

Bluffton, Ohio.

Home Made Crankpin Oiler

A simple and effective centrifugal crankpin oiler can be made according to the accompanying figure. The plate *B* forms the cap for the crankpin. Solid with this plate is the boss *E*, and the whole is held in place by the center bolt *F* and a dowel pin. The bolt, of course, has a hole extending through it and communicating with an oil hole in the pin as shown.



CONSTRUCTION OF THE HOMEMADE CRANKPIN OILER

It will be seen by the end view at the right of the figure that the quill *C* for delivering the oil may be adjusted both vertically and horizontally by means of two setscrews as shown.

C. R. MCGAHEY.

Baltimore, Md.

Used Wrench on Throttle Valve

The 6-in. throttle valve of a 750-hp., cross-compound Corliss engine began to leak, and when shutting down the engine a wrench was used on the handwheel to turn it tight. Things went along nicely, outside of a little rattle in the valve, until one night, when the night engineer started to shut down; he found that he could not shut off steam with the throttle valve and had to use one on the main header.

Upon examining the valve it was found that the disk was off, the spindle threads had been stripped and a pin had sheared. As the engine was needed, the engineer put the disk back on the stem, put a bolt through and beaded over the end on the nut. This answered for about three weeks, when the relief valve on the receiver started to blow, owing to the high receiver pressure caused by the bolt breaking. The end with the nut caught on the crank-end steam valve and twisted the stem, which allowed steam to blow through to the receiver.

The engine was stopped in time to prevent any further damage. The valve stem was heated in the furnace, the end up as far as the keyway being kept cool so as to prevent distortion of the keyway, which was all right. The end of the valve stem was gripped in the vise and, using a 24-in. monkey-wrench, the tee head was twisted back to its original position; when assembled it was found to have the right amount of lap.

The throttle-valve disk was trued up in a lathe, and a thread cut in the hole for the valve stem; a new stem was made and riveted in place, and when assembled the valve was found to be steam tight when shut off by hand. The use of the wrench was discarded and since then there has been no trouble with the valve.

THOMAS SHEEHAN.

North Adams, Mass.

Auxiliary Valve Stem

A 4-in. bypass valve is located beneath the floor of our power house, and having to open it every time the waterwheel is started, I devised a way of operating it without going below.

Taking the handwheel off of the valve stem, I filed the end of the stem square, and drilled a hole through the floor large enough to let a 1-in. pipe through. Then cutting a piece of 1-in. galvanized pipe of the required length, I hammered the burr in, and slightly dented the pipe on each side, placed it over the square end of the valve stem and ran hard babbitt metal about 2 in. deep in that end. I then drilled a ½-in. hole in the other end, and put in a ½-in. piece of round iron, 9 in. long, for a handle.

I can now open or shut the valve without trouble, and as the extra stem is slipped off after using, it is not in the way, and the floor is left clear of any obstruction.

V. C. WOOD.

Copenhagen, N. Y

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

A Pumping Problem

All of the letters in the issue of Jan. 23 on the centrifugal-pump problem were shots in the right direction, but none brought out the fundamental principles involved in the question or the reason why.

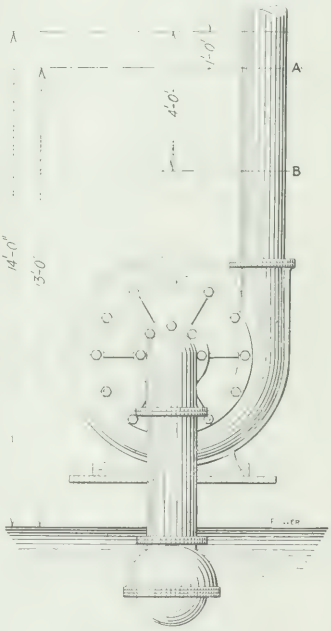
Mr. Dowd is correct when he says that all pumps do not overload. A pump can be designed that will not overload, even though the static head be suddenly and completely removed.

There should be two distinct classes of centrifugal pumps. One should be designed for variable speeds, intended for use where there are no sudden changes of static head and the speeds of the pumps are fixed according to the static heads. The other should be constant-speed pumps intended to be connected to constant-speed drivers and where the static head is liable to change suddenly. The majority of centrifugal pumps are neither one nor the other; they are hybrids, with the faults of both types and without the virtues of either.

In the following explanation, to avoid complicating the theory, I will neglect pipe friction and the resultant velocity of the water; that is, the resultant of the radial flow and the linear velocity at the periphery of the impeller. Assume a pump having impeller vanes of an angle of 90 deg. This pump has a discharge pipe run up to an indefinite height; see the accompanying figure. The pump is primed and started up and run at a given number of revolutions; the peripheral velocity of the impeller will be, say, 30 ft. per second, and the water will rise in the discharge pipe until it comes to rest at a point balanced by the 30 ft. per second, $V^2 \div 2g$, which would be 14 ft.

In reality the water would not come to rest, it would surge up and down; but to make this explanation clear I will consider that an equilibrium is established. This 14 ft. would then be the total head that the pump was capable of at the given speed. Now, suppose the pipe were cut off at *A* 1 ft. below this point, then the water would flow at a velocity due to the difference of heads, which, in this case, would be 8 ft. per second. Consider that this is a 20-in. pump and pipe, then this pump would deliver approximately 7840 gal. per minute against a total head of 14 ft. and the water horsepower would be about 27.7.

Now suppose that the pipe be cut again at *B*, a distance of 4 ft. from the point of no flow. Then the water would run off at a velocity due to 4 ft. $V = \sqrt{2gh}$ would be approximately 16 ft. per second and the pump would be delivering 15,680 gal. per minute, but the total head would not be reduced at all; it would still be 14 ft., which would consist of 10 ft. of static head plus 4 ft. velocity head. The water horsepower



ARRANGEMENT OF PUMP, SHOWING HEIGHT OF LIFT

would be just double, or 55.4. This is in exact accordance with Bernoulli's theorem—that the sum of the static head plus the velocity head will always equal the total head.

These exact conditions are merely assumed for the sake of clearness; as a matter of fact, if the friction head were considered it would simply reduce the velocity head but would add a corresponding amount to the pressure head and the total head would remain unchanged. If the resultant velocity be considered, as the flow would be increased by a lower static head the resultant velocity would be greater and the total head would be increased. Thus it is evident that not only would the amount of water be increased when the static head is decreased and the pump kept at a constant speed, but the total head, instead of being less, as claimed by some, is not decreased.

If the vanes had a backward rake there would be a tendency to reduce the total head, but if the area of passages between the vanes was large this reduction would be small and there would still be a tendency to overload when the static head is reduced.

WILL I. BETTIS.

Houston, Tex.

Measurement of Hot Feed Water

I read the articles which appeared recently on "Measurement of Hot Feed Water" and was much surprised that no mention was made of the "Lea" V-notch recorder.

The V-notch method of measuring hot water seems to be growing in favor among engineers because of its simplicity, accuracy, freedom from error due to collections of sediment and deposits of scale, its compensating feature for changes in temperature and because there are no moving parts coming in contact with the flow, except the float which operates the recorder; this is placed in a chamber by itself and is completely protected from the flow.

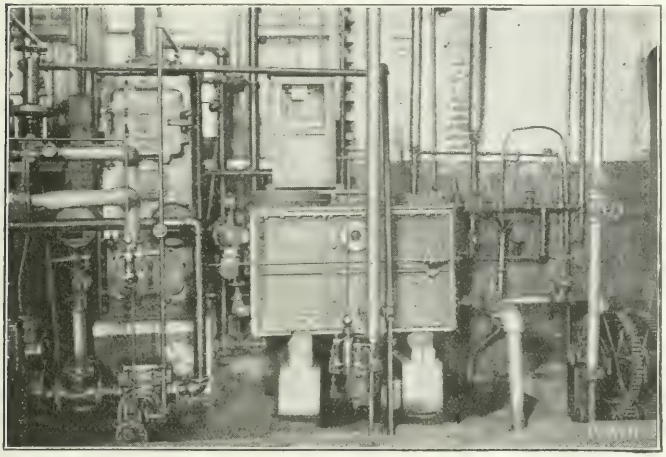
Like the venturi meter and the Pitot tube, the V-notch recorder is a continuous-flow meter. The fact that the V-notch recorder has a storage tank to contain the weir explains one reason why it is meeting with success in power plants; this storage of hot water requires a considerable interval of time to change its level, and this change of level gives an opportunity for the recording apparatus to properly adjust itself. In other words, the V-notch recorder has a dampening effect on the record of the fluctuations in the load.

The recorder is always placed on the suction side of the feed pump and hence the whole apparatus is at atmospheric, or very near atmospheric, pressure, and is readily accessible for cleaning and repairs. With the recorder is also provided a chart having rectangular coordinates which many consider an advantage because it can readily be filed and a standard planimeter may be used to measure the area of the chart and

thereby calculate the quantity having flowed through the recorder during any period of time.

As far as we know, there is no apparatus which can so readily be checked as the V-notch recorder, because by a pointer attached to the float rod in front of a scale the actual head in inches going over the weir may be seen at any time. This value may be substituted in Thompson's formula for the V-notch and the result compared with the indicated rate of flow on the calibrated drum of the recorder or on the chart record.

Some engineers feel that the weighing machines of the dumping-bucket types are preferable to the other hot-water meters because they give on a counter



A "Lea" Recorder in Service

dial the total quantity which has flowed through the machine. If this is the only result they are seeking, such information is undoubtedly given, but in the operation of a power plant is it not very much more important to know the fluctuating condition of the load as well as the total load on boilers and turbine or engines, as the case may be?

The fireman or water-tender can by glancing at the chart see whether the rate of feed has been as constant as the load, and if not, he can exercise more care as to the regulation of the feed pumps. This one principle alone—viz., uniform rate of feed—will, I believe, be found to be one of the most important factors in obtaining a high evaporation and one which is most neglected in the smaller plants. Is it not only by such an analysis of the load as provided by a recorder chart that economical and efficient working conditions may be established and accurately checked from day to day?

Arthur C. Jackson,
of the Miller Lock Co.
Philadelphia, Penn.

Copper Crosshead Shoes

The letter in Power for Jan. 23 relative to copper-lined crosshead shoes reminds me of an experience I had in putting into operation the power plant of a portland-cement works.

This plant contained four heavy-duty Corliss engines, two simple, 24x48 in. and two cross-compound 24 and 48 by 48 in., having copper-lined crosshead shoes. During my absence one of these shoes heated (from lack of sufficient oil, probably, as the engines had only been in operation a few days) and fire flew, in spite of all the attendant could do, until the engine was stopped. According to his report, less than one minute's time elapsed between the smoke and the fire.

The copper was found to be so hard in spots that neither a file nor a chisel would take hold, and it was necessary to grind these spots off on an emery wheel. The guide was badly scored up during the accident and it was necessary to substitute babbitt metal for the copper before the engine could be operated again.

No serious trouble was experienced with any of the other copper shoes, but after three years' continuous service, the scored guide with the babbitted shoe showed almost imperceptible wear, while the other guides were worn down $\frac{1}{16}$ in. and more. On the other hand, the copper shoes were worn off less than $\frac{1}{8}$ in. while the babbitted shoe had been relined twice.

I believe that yellow brass makes the best lining for crosshead shoes, as it is better that the lining of the shoes should wear than the guide; and while babbitted shoes are too soft, the copper will be found too hard in most cases.

J. W. Fowler.
Nashville, Tenn.

I noticed what C. L. Johnson had to say regarding the merits of the copper crosshead shoes, in the Jan. 23 issue. Copper, while very soft, or close grained, is very tough, while babbitt does not possess this quality and would have offered less resistance if it had been employed. In other words, it would have commenced to flake and "ball up" under the shoe from the effect of the grit.

Lloyd V. Beets.
Nashville, Tenn.

What Means the Dome?

Referring to the article in Power of Dec. 26, John Francis' comment in the issue of Jan. 30 is about correct.

There are probably but few old-timers left who fired the pigmy locomotives back in the sixties, like myself. The cylindrical part of the boiler was small and the steam space above the water line was often less than 10 in. The throttle valve was placed in the top of the forward dome to get as dry steam as possible; the second dome was available for steam if the water level was not too high, giving the advantage that would accrue from one large dome. The single large dome over the firebox soon replaced the double style, and steam pipe and throttle valve were placed in the top, just beneath the old spring balance safety valves.

E. Stanley Thomas.
Fremont, Ohio.

Either is Right

My attention has just been called to an editorial filler in Power, for Jan. 2, to the effect that if one wanted to know whether the name of the Stirling boiler is spelt with an "i" or an "e," he could not find out from my paper on the Delray tests.

I wish to point out that all Stirling boilers are sterling, and that he would be right with either spelling.

D. S. Jacobus.
New York City.

Engine Load Not Equalized

Harry H. Gordon, in the issue of Jan. 23, makes inquiry about equalization of load between the high- and low-pressure cylinders of a 14 and 28 by 36-in. noncondensing steam engine.

In the first place, if the diagrams were taken simultaneously and represent the average load on the engine, it is too large for its work, which accounts for the loop in the low-pressure diagram. Next, the engine was originally designed for a condensing engine and the cylinder ratio is too high for running noncondensing. This accounts for the long cutoff in the high-pressure cylinder, with excessive terminal drop (apparently about 40 lb.), although the engine carries so light a

load as to form a negative loop in the low-pressure diagram.

The receiver pressure is too low, and should be about 10 lb. higher for a non-condensing engine carrying 130 lb. gage steam pressure. If the receiver pressure were raised which may be done by shortening the low-pressure cut-off, it would go quite a ways toward work equalization and would also lessen the terminal drop in the high-pressure cylinder. There seems to be considerable loss of both pressure and volume between the cylinders, and the terminal pressure in the low-pressure cylinder is much lower than should result from the long cutoff in the high-pressure cylinder. This indicates leakage or excessive condensation, or both.

A cylinder ratio of about 3, a somewhat smaller low-pressure cylinder, say a 15 and 26 by 36-in. engine, would probably have been more satisfactory.

WILLIAM E. NINDE.

Syracuse, N. Y.

Repair Work Suggestions

The figure accompanying Joseph F. Pflum's letter, in the Jan. 30 issue, shows ⅞-in. studs inserted in the spokes crosswise of the fracture. The job probably would have been improved if he had drilled and tapped the rim of the wheel for the proper size studs, as shown in Fig. 1.

I once assisted in repairing a large

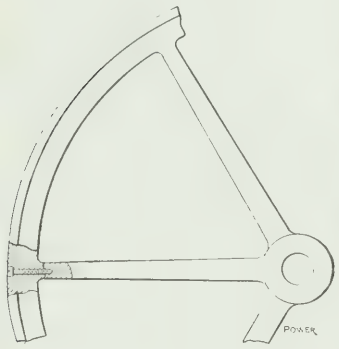


FIG. 1. SHOWING BETTER POSITION OF HOLDING BOLT

pump gearwheel which had a crack in the rim. Referring to Fig. 2 and assuming that the crack was at point *A*, we first notched out the spokes at *B* so as to afford a good bearing for the U-bolts shown at *D*, which were fitted on and turned up tight with a pair of turnbuckles.

Another method of repair which we used on smaller gears is shown at *E*, Fig. 2. We bent two heavy strips of iron to conform to the inner surface of the wheel rim, and drilled two holes in each end of the strip so that they would come a safe distance away from the crack. We then laid them in the rim of the wheel, one on either side of the boss, if there was any, and fastened them firmly with capscrews, set up good and tight.

In case a piston rod or a driving rod is broken short off and it is impractical to weld it, a good scheme to use is illustrated in Fig. 3. Take the longer part

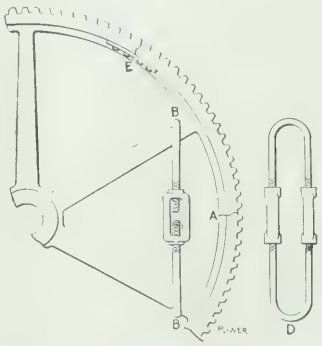


FIG. 2. METHOD OF REPAIRING GEAR WHEELS

F of the rod, and chuck it in a lathe; turn the broken end off square, drill and tap it as at *G* and fit on a new end piece *H*, which has been cut to the proper size and threaded on the end. Should there be any unevenness at the joint, the whole job can easily be trued up in the lathe, after which not only will it be

FIG. 3. METHOD OF REPAIRING PISTON ROD

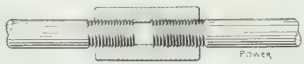


FIG. 4. METHOD OF REPAIRING ECCENTRIC ROD

hard to tell where the splice is, but the rod will run with perfect smoothness through a stuffing-box or gland.

In the case of an eccentric rod or one subjected to vibration as well as endwise pull, I would use the methods illustrated in Fig. 4. The ends are turned up and threaded. Then a piece of shafting ¾ or 1 in. larger in diameter than the broken rod and of sufficient length to give the job proper strength is drilled clear through and tapped for each end. Should the conditions demand great rigidity, a longer thread may be cut on the ends of the rod and a jam nut put on either side of the sleeve

THOMAS M. STERLING.

Middlebranch, Ohio.

Personal Appearance

The foreword in the Jan. 23 issue is very good and much needed at this time. If the engineer of the small plant who is trying to get a deserved increase in salary would take more interest in his personal appearance as well as that of the plant, he would stand much higher in the estimation of his employer and help to better conditions.

If a supplies salesman came into your plant dressed in dirty clothes and looking as sloppy as many engineers do while on duty, it would lower your estimation of his goods beneath those of his competitors. No one realizes this better than the salesman. When an engineer goes to the office to ask for an increase or for new equipment, wearing overalls over his underwear, as many do, with a piece of greasy waste hanging from a jacket pocket and an old dirty cap and dirty hands and face, his arguments will carry but little weight because his appearance has a great effect on the strength of the arguments.

A boiler inspector's job is long, dirty; yet his appearance in the office is as good as that of the boiler salesman, and he is respected.

The engineer has a great many dirty jobs to do, but when the work is completed he can usually find time to clean himself.

J. C. HAWKINS.

Hyattsville, Md.

Central Station vs. Isolated Plant

The solicitor for the central station tells a very nice story of how much can be saved, etc., and I am very sorry to say that in some cases the engineer is unable to show that these statements are not true. Here is a case, however, which I think should show the owner of a plant of any size that there must be some saving in the isolated plant.

The largest group of buildings in this city has been served by an isolated plant for years, and when the central-station company was formed some years ago the owners of these buildings were interested in this company. In course of time a large addition was built to the building which the central-station company occupies and for which it furnishes light and power. For some reason, I do not know what, two new engines were put into the new part and a large sum of money was spent in making the engine room uptodate. Now why, if central-station power is so much cheaper and better, did they not use it in the extension?

C. L. JOHNSON.

Newark, N. J.

An interesting editorial, that, in the Feb. 13 issue, entitled "How the Central Station Got One Plant." It seems to me

that there is something to be read between the lines. Who really was the loser? It is true that the engineer lost his job, and those of the men under him. But that loss was only temporary, for it is fair to assume that at some time they would all be employed again, somewhere.

How about the employer who evidently hastily decided that the central station was the thing for him? Did he not "cut off his nose to spite his face"? His loss is probably one that will continue, even though he may not be aware of it, for it is likely that the plant could have made good if properly managed.

POWER has told engineers a lot of things concerning the proper operation of steam plants, and how to hold their own against possible invasion, and, no doubt, many engineers have profited by acting accordingly. It is now time to start a campaign of education among owners, employers and managers, and try to open their eyes.

The central station has begun its course of education with owners, but there is another side to the story which they should hear before doing as the fellow did in the editorial.

CHARLES J. MASON.

Scranton, Penn.

Uniform Boiler Laws

I was interested by the editorial in the Feb. 6 issue on the subject of "Uniform Boiler Laws," and if the American Boilermakers and Manufacturers' Association can bring these into existence it will earn the eternal gratitude of the boiler manufacturers in this country and be instrumental in providing great protection to steam users as well. I doubt, however, whether it will be possible to get concurrent legislation on the part of the states.

Although Congress could not make an enactment that would interfere with the rights of any state, it could appoint a commission to prepare a uniform law which would be known as the United States standard for stationary boilers. The adoption of this standard need not be made obligatory, and I believe that in a short time public sentiment would compel the different states to adopt it.

The present condition of affairs, due to recent state legislation as well as municipal regulations, makes confusion worse confounded for the boiler manufacturer. It also makes it a hardship for certain classes of steam users; for example, a contractor doing business in several states of the country cannot very well afford to discard the boiler on his hoisting machinery because it does not conform to the regulations governing the territory in which he has a contract. In my opinion, the only way to accomplish the desired legislation will be by establishing a United States standard.

JOHN DICK.

Meadville, Penn.

Lubricator Piping and Lubrication

In the answer to D. C. Y.'s inquiry on lubricator piping it is stated that "The lubricator pipe should not extend into the steam space of the main pipe, but should end so that the oil will run down the side of the pipe."

This is directly opposed to all accepted practice, for if the oil is allowed to run down the side of the pipe, it will not spread sufficiently to oil one-half of the frictional area in the valve chest and cylinder. On the contrary, the pipe should extend into the main steam pipe to its center and end in a slight downward curve to prevent the oil from following back on the pipe; then the temperature and velocity of the steam will cause the oil to atomize and impregnate the steam, and thus it is carried by the steam to all parts of the steam chest and cylinder.

E. H. ROBERTS.

Norwalk, Conn.

Changes Necessary

J. D. Gilmore asks, in the Feb. 13 issue, what the readers think of his indicator diagrams. For a medium-speed engine they are not bad. As to what adjustments are necessary, if the engine is running quietly, it would be well to leave it as it is. There are certain standards for indicator diagrams, such as vertical admission lines and appreciable compression.

At both ends of the cylinder the steam-valve opening occurs late. Under a heavier load the governor might correct this, but as the diagrams show approximately one-third cutoff, the arrangement of engine parts should be such as to give a free admission at this point of cutoff.

To correct this late admission there are two factors to consider, the governor and the steam valves. Block the governor into position as for lightest loads and shortest valve travel; then turn engine over, observing the steam valves. They should come line and line with the edge of the port, without opening and without lap when in extreme opening position. If there is lap, the steam connection rods can be adjusted to bring the steam valves line and line. Correct the front end first and then the back end.

If the steam valves are correct, the fault lies in the governor. To correct this, an offset key will be required that will allow the governor to advance or give greater lead. It is hard to say how much this advance should be. As it is fairly safe to assume that the engine builder keyed the governor in the proper position, the probabilities are that the steam valves will be found to be out of adjustment.

The diagrams show that compression occurs earlier at one end than at the other. This can be corrected or equalized by adjusting the length of the exhaust eccentric rod or the exhaust reach rod to give earlier closing at the former and later at the latter. After this, if it is desired to increase the compression in both ends, shorten the exhaust reach rod slightly and lengthen the connection rod between the exhaust valves by an amount twice as much as the reach rod was shortened.

J. K. MCINTYRE.

Newburgh, N. Y.

The diagrams shown in the issue of Feb. 13 by Mr. Gilmore indicate that the engine is operating under a rather heavy load. Moving the eccentric ahead on the shaft in the direction in which the engine is running will sharpen up the admission line and improve the diagrams considerably.

C. R. MCGAHEY.

Baltimore, Md.

Various Comments

I think if J. D. Gilmore will move the eccentric of his engine ahead, the diagrams will be good. The steam valves are late. There may be some other little adjustments needed, but it is hardly safe to advise until the greater fault is corrected.

My experience with gage-glasses on traps and separators is the same as that of J. W. Dickson and Edgar Altman; it is quite impossible to keep them in even when the pressure is moderate.

I think Mr. Strachan's cure for hot bearings is the most novel I ever heard of; if it cures, all right. I think that a little fine abrasive, like grindstone grit or Sapolio, will cut away the high spots and when the bearing is good the trouble always disappears.

When there is a knock, I give the box that appears to be the offender a liberal dose of oil; that will usually deaden the noise. Then I make a pencil mark across the key and gib and drive the key the width of the mark. If this is not enough it can be repeated the next day.

I have been in my present position five years and have had no trouble from hot bearings in that time. I have one 26 and 48 by 72-in. cross-compound and one 20 and 36 by 60-in. cross-compound engine running at 60 and 70 r.p.m., and doing about 2000 hp. Four gallons per day of oil, costing 14c. per gallon, with ordinary oil cups, oil these engines as well as all the auxiliaries. Does not this speak well for the man who looks after the oiling?

If Scott Norton, when punching out bolt-holes in sheet packing, will do his cutting on the end of the grain instead of the side of the board, he will find that his punches cut much better as the wood is more solid.

J. SWALLOW.

Utica, N. Y.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Cement for Leather Belts

What is a good cement for leather belts?

R. W.

Place equal parts of common glue and isinglass in a glue pot and add sufficient water to cover the whole. Let it soak for 10 hours and then bring it up to a boiling heat. Add pure tannin until the mass looks like the white of an egg. Apply warm.

Oil Switch

What is an oil switch for, and how is it operated?

M. G.

An oil switch is similar in its action to other switches, except that its contacts are immersed in a small tank of oil. It is used principally on high-tension voltage service; the large arc which would result from breaking a high-voltage line with an ordinary switch, is almost entirely eliminated by the oil which flows between the contacts of an oil switch when opened. The oil has a high electrical resistance; it is a mineral oil free from acid and water.

Sulphur Dioxide as a Refrigerant

How does sulphur dioxide compare with ammonia as a refrigerant?

F. M. M.

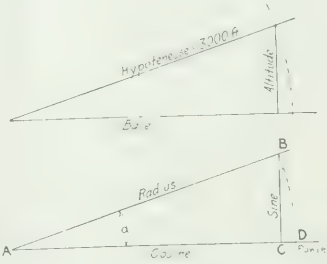
Sulphur dioxide gives a low efficiency at very low refrigerator temperatures, and requires about three times as much compressor capacity as ammonia. In tests made by Shroder and Denton, on sulphur dioxide with a condenser temperature of 80.6 deg. F. and a suction temperature of — 15.9 deg. F., the ice-melting capacity per pound of coal was 10.1 lb. and the per cent. loss due to cylinder superheating was 39.2. With ammonia having a condenser temperature of 84.6 and a suction temperature of — 10.4 deg. F. the ice-melting capacity per pound of coal was 14.5 lb. and the per cent. loss due to cylinder superheating was 22.9.

Base and Altitude

What are the base and altitude of a figure whose hypotenuse is 3000 ft. long and the angle 12 deg.? What would they be if the angle was 22 deg.?

P. J. D.

The arc of the circle in the illustration is drawn with the radius *AB*. The line *BC* dropped from the extremity of one radius perpendicular to the other radius *AD* inclosing angle *a* is the sine of that angle. The line *AC* between the center *A* of the circle and the intersection *C* of the sine is the cosine. For a given



angle, the lengths of these lines will have a definite relation to each other, and these relative lengths are given in the table of trigonometrical functions, the length of the radius being taken as unity. In the problem, if the hypotenuse is taken as the radius, the altitude will be the sine and the base the cosine.

The table gives the following values:

Angle	Sine	Cosine
12	0.2079	0.9781
22	0.3746	0.9272

This means that for an angle of 12 deg. the sine is 0.2079 of the radius and the cosine is 0.9781 of the radius. Since the radius or hypotenuse is 3000 ft., the base and altitude of the 12-deg. angle are

Altitude $0.2079 \times 3000 = 623.7$ *ft.*

Base $0.9781 \times 3000 = 2934.3$ *ft.*

and for the 22-deg. angle the base and altitude are

Altitude $0.3746 \times 3000 = 1123.8$ *ft.*

Base $0.9272 \times 3000 = 2781.6$ *ft.*

Low Pressure Cylinder Valves

How can the valves of the low-pressure cylinder of a cross-compound engine be prevented from slamming on their seats when running light all day, with a 2-in. vacuum on the receiver gage?

J. M.

Try raising the receiver pressure by making the cutoff in the low-pressure cylinder a little earlier.

Steam per Horsepower Hour

If the duty trial of a triple-expansion steam pump was 123,000,000 ft.-lb. per 1000 lb. of steam, what is the steam consumption per indicated horsepower-hour?

C. F.

Assuming the mechanical efficiency to be 90 per cent., the foot-pounds developed in the engine cylinders would be

$$\frac{123{,}000{,}000}{0.90} = 136{,}666{,}666 \text{ ft.-lb.}$$

per 1000 lb. of steam, or

$$\frac{136{,}666{,}666}{1000} = 136{,}666.7 \text{ ft.-lb.}$$

per pound of steam, or

$$\frac{136{,}666.7}{60 \times 33{,}000} = 0.069 \text{ hp.-hr.}$$

per pound of steam, the reciprocal of which would be the pounds of steam per horsepower-hour, or

$$\frac{1}{0.069} = 14.5 \text{ lb.}$$

of steam per horsepower per hour.

Heating the Feed Water

If the steam pressure is 90 lb. and the initial temperature of the feed water is 60 deg., what saving in fuel may be expected by heating the feed water to 208 deg. F.?

P. F. B.

To find the saving by heating the feed water a given amount, divide the difference in the total heat of the water above 32 deg. before and after heating by the total heat required to convert it into steam from the initial temperature. Multiply the quotient by 100 and the product will be the percentage of saving to be expected. In 90 lb. gage pressure or, say, 105 lb. absolute, there are 1187.2 B.t.u. above 32 deg., and water at 60 deg. F. contains 28.08 B.t.u. Therefore steam at 105 lb. absolute pressure contains

$1187.2 - 28.08 = 1159.12$ *B.t.u.*

above 60 deg. This is the amount of heat which the boiler would have to supply to make a pound of steam from the given initial temperature. Water at 208 deg. F. contains 175.98 B.t.u. Thus $175.98 - 28.08 = 147.9$ B.t.u. are supplied by the heater, saving $147.9 \div 1159.12$ of the heat required or

$$\frac{147.9}{1159.12} \cdot \frac{100}{} = 12.76 \text{ per cent.}$$

New Pumping Engines for N. Y. City

Description of the two 18,000-000 gal. horizontal triple-expansion pumping engines recently installed at the Ninety-eighth St. station for pumping into the city main.

During 1908 it became evident that the pumping capacity of the Ninety-eighth Street pumping station of New York City would have to be practically doubled in order to meet the demand. The increased pumping capacity was made imperative not only because of the natural increase in the population of the territory served, but also because of territory being added to that already supplied.

The pumping station is situated just west of Columbus Ave. and extends from Ninety-eighth through to Ninety-seventh St. and has an extreme length of 199 ft. 8 in. and a width of 50 ft. The room in which the pumping apparatus is installed is about 81 ft. long by 50 ft. wide, the remainder of the station being occupied by the boilers and other apparatus.

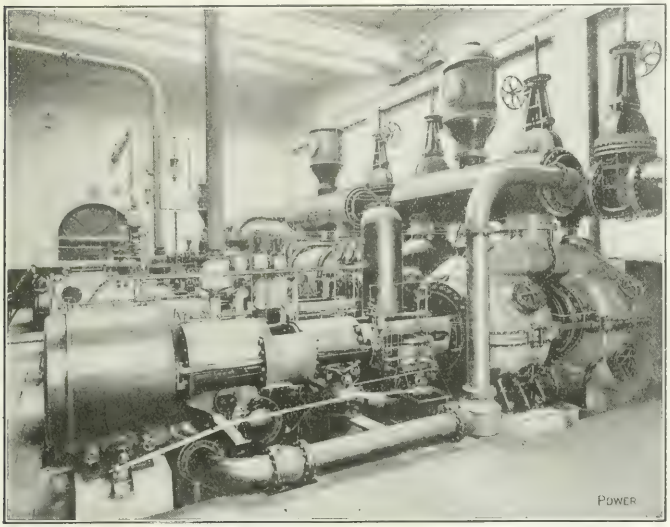


FIG. 1. GENERAL VIEW OF PUMPS

The pumping equipment, at the time the enlargment was contemplated, consisted of a Worthington horizontal high-duty compound condensing engine, installed in 1890, and two Worthington horizontal low-duty compound condensing engines, installed in 1879. The delivery of the former was 10,000,000 gal. and of the two latter, 7,500,000 gal. each, making a combined pumping capacity of 25,000,000 gal. per 24 hr.

The city desired to retain the 10,000,-000-gal. engine and replace the other two with new and larger machines. The problem was then resolved into the selection of an economical type of engine, two of which could be installed in a space 39 ft. long by 43 ft. wide (the space occupied by the two old engines). A further complication was the fact that only one old engine could be replaced at a time, the other being left in operation until the first new engine could take up its work.

As the increased capacity contemplated made it necessary to enlarge the suction and delivery mains within the station, and to so arrange them that it would be possible to deliver the water to the city mains, running parallel with Ninety-seventh and Ninety-eighth Sts., and as the station was not then equipped with a crane, although one has since been installed, it can be readily seen that there were mechanical difficulties in the way of making the change.

The specifications as prepared by the Department of Water Supply, Gas and Electricity covered two 18,000,000-gal. triple-expansion, direct-acting pumping engines, complete with foundations, condensers, primary heaters, main steam piping and auxiliary steam and water piping, supports and all other appurtenances ready for regular service. The duty of each engine was to be not less than 100 million foot-pounds of work performed, per thousand pounds of dry steam consumed by the engine and its condensing apparatus, when working under a steam pressure of 150 lb.

To meet these conditions, two Worthington horizontal triple-expansion direct-acting pumping engines were selected. These are shown erected in Fig. 1. Each engine has two 15-in. high-pressure, two 23-in. intermediate-pressure and two 38-in. low-pressure steam cylinders, and two double-acting water plungers each 34 in. in diameter with a common stroke of 24 in.

There are three steam cylinders on each side, the low-pressure cylinders being outboard and the high-pressure cylinders being nearest the water cylinders. The cylinders are placed in line with the pumps and are secured to them by heavy cradles in such manner as to make the engine self-contained so far as all working stresses are concerned. The arrangement of the piston and plunger rods is such that each steam piston or water plunger may be inspected or removed by merely taking off the head of its own cylinder, as shown by Fig. 2.

The steam valves are of the Corliss semi-rotative type, placed underneath the cylinders. This insures good drainage, as any moisture carried over by the steam does not enter the cylinders, but passes out at once through the exhaust, thus avoiding the use of drip valves or drains of any kind. The cutoff valves are placed in the high-pressure steam cyl-

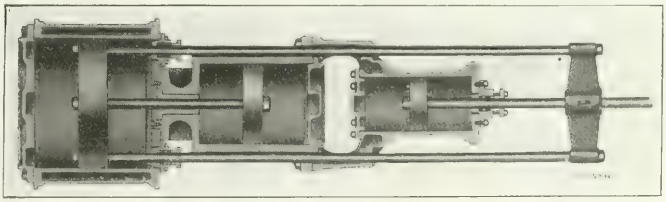


FIG. 2. SECTION THROUGH CYLINDERS

inders only and are set to cut off at from one-half to three-quarters of the stroke.

The water ends are of the outside, center-packed plunger type, having valves of the usual voluntary type, which are arranged in decks around the plungers instead of in horizontal flat decks. This construction was necessary in order to confine the length and width of the water ends to the smallest practical limit.

The condensing apparatus consists of a surface condenser placed in the discharge of each engine, the products of condensation being removed by vertical duplex double-acting air pumps, driven from the main rock shaft of each machine.

The primary heater is placed in the main exhaust line of each engine, between the low-pressure steam cylinders and the condenser. The heaters are of the straight-tube type with one end of each tube fixed in a tube head in the usual manner and the other end fixed in a floating head, which construction compensates for expansion and contraction.

DATA FROM DUTY TRIALS

	No. 1	No. 2
Duration of test, hours	24	24
Revolutions per minute	33.46	33.67
Length of stroke, inches	24.58	24.45
Piston speed per minute, feet	137.05	137.18
Steam pressure, pounds per square inch at engine	153.72	153.67
Vacuum in condenser, inches of mercury	27.42	27.39
Barometer reading, inches of mercury	30.28	29.94
Moisture in steam, per cent.	1.68	1.80
Air pump and jacket water corrected, pounds	147,077	151,203
Discharge pressure, feet	125.84	125.24
Suction pressure, feet	26.62	23.69
Distance between gage centers, feet	10.3	10.3
Total net head, feet	109.52	111.85
Total water pumped (meter), gallons	18,544,300	18,460,000
Duty per 1000 pounds of dry steam	115,519,950	113,884,400
Excess duty made above specifications, per cent.	15.16	13.88
Slip, per cent.	0.31	0.24

The accompanying table shows the results of the duty trials on the two pumping engines.

Edison Rate Discrimination Hearing

An interesting bit of information was brought to light in connection with the New York Edison rate-discrimination case at the hearing before the Public Service Commission on Feb. 29. At the previous hearings little or no damaging evidence was brought out, owing to the attitude of the company's officials in refusing to answer relevant questions and the commissioner's apparent lack of power to compel them to do so.

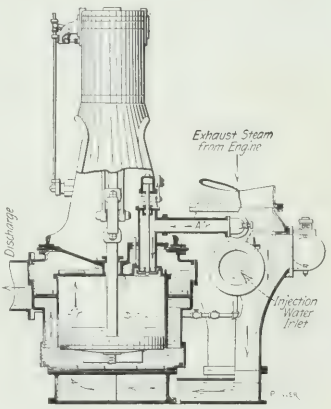
But a new factor has now been introduced into the case in the form of the New York Service Co. Its vice-president and general manager, Mr. Martin, testified that the New York Service Co. did a strictly supervising business and was in no way subsidiary to or connected with the New York Edison Co. He later admitted, however, that the principal business of his company was to investigate and report upon the cost of steam heating in private plants at the request of the Edison Co. For this service a monthly bill is rendered at cost, based upon the time of those concerned in the work. No profit is added to the bills, for, according to Mr. Martin, the company makes its profit in other ways, although just what other ways he refused to divulge.

The only plant which the New York Service Co. admitted supervising at present was that at the corner of Pine St. and Broadway. Here it operates the heating plant and buys electricity from the Edison Co. It sells the latter to the owners at cost and claims to make its profit on the heating alone. According to this, it must make such a large profit during the comparatively short heating season (to use the Edison Co.'s own argument) that it can afford to operate during the rest of the year at cost.

Twin Vertical Double Acting Air Pump

This pump has a flexible and independent control, and pistons have been substituted for the buckets, making each cylinder double acting.

The operation of the combined wet- and dry-vacuum cylinders with the auxiliaries is as follows: Water is pumped from the bottom of the condenser by the bottom end of the pistons into the bottom of the cylinders and into the annular main discharge.



TWIN DOUBLE-ACTING AIR PUMP

Air is pumped from the top of the condenser by the upper end of the pistons into the air cylinders and is exhausted into the main discharge outlet. There is a small amount of water injected into the top of the air cylinders to seal the air pistons and fill the clearance at the extreme upper stroke.

The piston rods, suction and discharge valves of both the air and water cylinders are water-sealed at all times. The suction and discharge valves of the water ends and the discharge valves of the air ends are in multiple and are automatically operated. The suction air valves, of which there is but one to each cylinder, are mechanically operated by means of a wristplate actuated from a walking-beam shaft and an automatically operated trip motion.

The steam chest is of a new design, and the short stroke and flutter of the pump is entirely eliminated. A vacuum breaker of the balanced double-valve type gives a very large opening.

This pump is manufactured by the Blake Pump & Condenser Co., Fitchburg, Mass.

Ratisal—a Substitute for a Trap

The accompanying figure shows the design of a device intended to handle water of condensation and which has been given the name "Ratisal" by its inventor, Heinrich C. Sommer, Nachfolger, Düsseldorf, Germany.

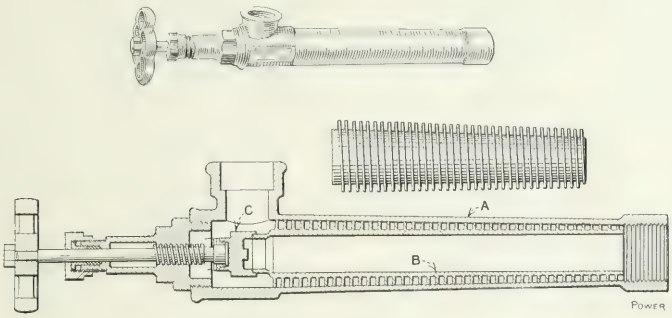
A tube-like conical shell *A* contains a removable tube *B* upon the external surface of which is formed a spiral screw as shown. During normal operating conditions the valve *C* is closed and the water of condensation is forced to find an exit through the sinuous canal of gradually decreasing cross-section formed by the spiral screw and the inner surface of the shell *A*.

As the canal is of considerable length, the frictional resistance offered to the passage of the water is almost equal to the pressure of the steam in the space being drained. By adjusting the sectional area of the canal the frictional resistance may be regulated so that the water will have any desired pressure as it emerges from the device up to within a small degree of that of the steam. For this purpose, two sizes of copper-wire spirals are supplied which may easily be wound into the screw to diminish the effective area.

If air is to be blown out of the system which the device is draining or if for any reason a temporary vigorous steam or water discharge is desired, the valve *C* is opened and a short-circuit is established through the central core of the tube *B*.

It is pointed out in the literature issued by the American sales agent for

"Ratisal," L. Scheidel, 39 Komorn St., Newark, N. J., that this device forces waste water through the drain pipe continuously and without loss of steam; the exposed or cooling surface is slight and hence the economy is high; the device can be attached to any water-producing point of a pipe or vessel containing steam, regardless of the volume of steam and the pressure. Its features are continuous operation, lack of moving parts and low cost and simplicity of installation.



DETAILS OF CONSTRUCTION

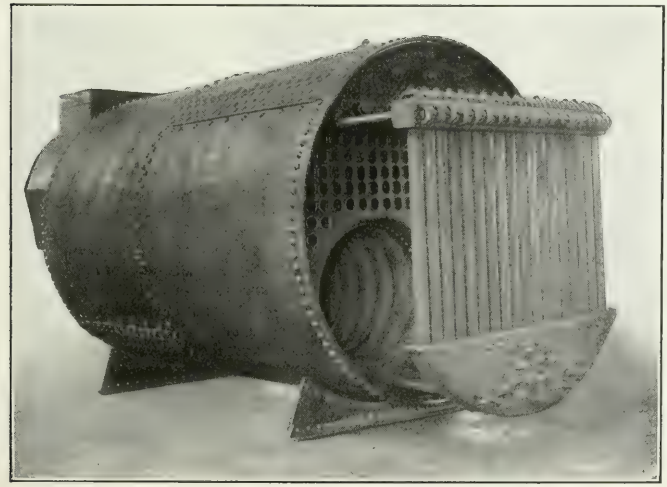
Circulating Attachment for Internally Fired Boilers

In recent issues of POWER the correspondence columns have contained letters on the dry-back marine boiler. It seems agreed that this type of boiler gives general satisfaction, and lacks but one essential qualification, namely, functional circulation. Not only does this fault cut down evaporation, but it also causes widely different temperatures to prevail at different parts of the boiler, causing severe and unequal strains and, sooner or later, leaky tubes and rivet holes.

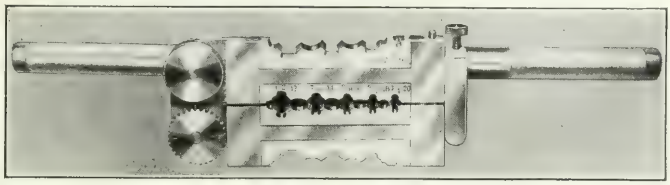
The water occupying the space below the grate level, or center of the furnace, is entirely removed from the action of the fire and is termed "dead" water. A standard 150-hp. boiler with one furnace contains about 21,000 lb. of water. Of this, 14,000 lb. is "live" water, or water in direct contact with the heat of combustion, while 7000 lb. is "dead" water. A standard 200-hp. two-furnace boiler contains about 32,000 lb. of water; of this, 22,000 lb. is "live" water and 10,000 lb. is "dead." These proportions hold good for all sizes of internally fired boilers and it will therefore be observed that practically one-third of the total weight of water is "dead," and its temperature is low as compared with that prevailing in the "live" water.

It would seem that the one thing needful, then, is automatic circulation, independent of auxiliary boilers, pumps, etc. The patented circulating attachment which is made and furnished on all boilers of this type manufactured by John Brennan & Co., Detroit, Mich., is designed to produce this. The accompanying figure illustrates the construction of the attachment. The furnace gases impinge against the upright tubes in the circulator and the manufacturers assert that from the moment the water begins to heat, the circulation is rapid, positive and continuous over the heated surfaces, which insures a practically even temperature throughout the entire boiler.

This attachment may be applied to boilers that have already been in service.



INTERNALLY FIRED BOILER WITH CIRCULATING ATTACHMENT



COWELL THREADER

Cowell Threader

This tool has been designed in a convenient size and is always ready to cut a thread over a range of sizes from $\frac{3}{8}$ to $\frac{3}{4}$ in. inclusive; it is illustrated herewith.

The hardened-steel removable die blocks are fitted into parallel jaws, adjustable as to distance between them. A calibrated wheel operates a cam, which changes, by a small variation, the distance between the jaws, to enable the tool to cut threads of greater or less than standard depth. The tool is 15 in. long over all, 2 in. wide and weighs $2\frac{1}{2}$ lb.

After the threads have been cut the threader is opened and removed, thus eliminating the danger of making an imperfect thread when backing off. This feature also avoids the danger of damaging the dies. The threader is manufactured by the Scott-Rose Co., Marquette Building, Chicago, Ill.

London, it is announced, has 7875 smoke-consuming furnaces using 54 different types of apparatus. The city has so far obtained 672 convictions for smoke nuisances.

License Revoked

The government inspectors have revoked the license of the chief engineer of the "Sara Dixon," on board which a boiler blew up on the night of Jan. 18. The "Dixon" was a small stern-wheel river boat running out of Portland, Ore. The explosion occurred at Kalama, Wash., on the Columbia River. A large portion of the deck and the pilot house were blown away, killing the fireman on watch in the boiler room and the captain and first officer, who were in the pilot house. The rest of the crew escaped to the shore in the small boat. The boiler was of the standard marine firebox pattern, built in 1908, and at the last inspection it was allowed 215 lb. working pressure.

At the trial it was brought out that the pressure gage indicated only 200 lb. at the time of the explosion. The chief engineer testified that he had examined the water level only a few minutes before the catastrophe and found it to be correct. Notwithstanding his testimony, the chief engineer was found guilty of negligence and his license was revoked.

Later, the first assistant engineer was also placed on trial, but the result has not been made public at the time of this writing.

Government Examination for Engineer

The Civil Service Commission announces an examination on Mar. 20, 21, 22, to fill the position of electrical and mechanical engineer, at from $1800 to $2000 per annum, in the quartermaster's department at large, New London, Conn., and vacancies requiring similar qualifications.

The examination will consist of these subjects:

Problems in algebra, integral and differential calculus, practical calculations, designs in electrical and mechanical construction, specifications covering electrical and mechanical engineering, construction and testing of electrical and mechanical apparatus, training, experience and fitness.

The appointee in this position must be competent to draw plans and specifications for power and electrical installations, superintend the installations, and make operating tests upon them, etc. Applicants who have not had at least five years' practical experience will not be admitted to this examination. Graduation in mechanical or electrical engineering will be considered as equivalent to two years of this period.

Applicants should at once apply to the United States Civil Service Commission, Washington, D. C., for application and examination Form 1312. No application will be accepted unless properly executed, including the medical certificate, and filed with the Commission at Washington.

Corrosion of Boiler Tubes

The National Tube Co., of Pittsburg, Penn., has recently issued a bulletin on the corrosion of boiler tubes. The material contained therein has been compiled from various sources, including a series of tests made some years ago at the company's laboratories under the direction of the Navy Department, and later tests, both laboratory and service, made by several individual companies.

These tests showed very little difference in pitting under similar conditions with wrought iron and steel, although some more recent indications have favored the latter.

SOCIETY NOTES

A gratifying expression of their appreciation of the interest of their engineers in their vocation, and in their efforts for self-improvement, was furnished by the employers of the members of N. A. S. E. No. 20 of Massachusetts, who united in presenting to that association an outside spring Robertson-Thompson indicator, with five extra springs, making it available for the wide range of work which it will find in association service. With it came a reducing motion and a copy of Pray's "Twenty Years with the Indicator." The box containing it bore a plate with the inscription, "To Fitchburg Association, Stationary Engineers No. 20, from their Employers." The gift was received by the association with a keen appreciation of the spirit which prompted its sending.

Nova Scotia Society of Engineers

The regular monthly meeting of the Nova Scotia Society of Engineers was held on Feb. 22 in the Nova Scotia Technical College, Halifax, N. S. C. H. Wright, of the Canadian General Electric Co., Halifax, addressed the society on "Electric Power Development in the Maritime Provinces," the lecture being illustrated by views from the reflectroscope.

BOOKS RECEIVED

STRENGTH OF MATERIALS. By H. E. Murdock. John Wiley & Sons, New York. Cloth; 308 pages, 5x7½ in.; 153 illustrations; tables. Price, $2.

STEAM POWER PLANTS—By Henry C. Meyer. McGraw-Hill Book Co., New York. Cloth; 219 pages, 5¾x9 in.; 67 illustrations; plates; indexed. Price, $2.

TWELVE PRINCIPLES OF EFFICIENCY. By Harrington Emerson. The Engineering Magazine, New York. Cloth; 423 pages, 5x7½ in.; indexed. Price, $2.

A PRACTICAL MANUAL OF STEAM AND HOT WATER HEATING. By Edward R. Pierce. Domestic Engineering Co., Chicago, Ill. Cloth; 339 pages, 5½x8¾ in.; tables; illustrated; indexed.

EFFICIENCY AS A BASIS FOR OPERATION AND WAGES—By Harrington Emerson. The Engineering Magazine, New York. Third edition, revised and enlarged. Cloth; 254 pages, 5x7½ in.; indexed. Price, $2.

CENTRAL STATION HEATING. By Byron T. Gifford. Heating and Ventilating Magazine Co., New York. Flexible leather; 268 pages, 6x9½ in.; 42 illustrations; 50 pages of miscellaneous engineering data and tables; indexed. Price, $4.

NEW PUBLICATIONS

ENGINEERING DIRECTORY FOR 1912; nineteenth edition. The Crawford Publishing Co., Chicago, Ill. Flexible leather; 1496 pp.; 4x6¾ in.; thumb indexed. Price, $5.

This directory measures fully up to the standard established during its nineteen years of publication. The classified section contains 3850 classifications of manufacturers' products, and for those seeking a reliable uptodate mailing list for this year's sales campaign, attention is called to the following:

Jobbers of mill and plumbing and heating supplies, dealers in plumbing, steam and mill supplies in Canada; jobbers of hardware and electrical supplies, lists of manufacturers' agents and manufacturers of heating and mill supplies; railway purchasing agents, leading U. S. architects, electric light and power plants, gas companies, water-works, trade associations, and a cross index to manufactured products.

The directory also contains the names of over 6000 manufacturers producing over 4000 varieties of engineering goods, and having more than 50,000 trade or brand names.

SUPERHEATING IN MARINE PRACTICE (Die Heissdampf-Schiffsmaschine); part 2. The superheater systems and also a collection of experimental data for the calculation of the dimensions of superheater, boiler, condenser and steam-piping equipment. By Carl Fred Holmboe. Published by Wilhelm Ernst & Son, Berlin, 1912; 71 pages; 46 illustrations, with tables. Price, 3.4 marks. (81 cents).

Part 1 of this work, a notice of which appeared in POWER for Apr. 5, 1910, deals chiefly with dimensions, steam and coal consumptions and constructive details of the marine engine. Part 2 takes up superheaters in their various forms and the measurement of their heating surfaces and that of the boilers and the cooling surfaces of the condensers, and includes a reference to chimney losses and the effect of superheaters on the draft and methods of improving the latter. Considerable information is given from actual experiences and from tests of marine installations under normal conditions of operation.

The general laws of the theory of heat are mathematically and practically dwelt upon and various styles of superheaters are shown and considered.

The details of rigid and flexible pipe joints and the heat loss by piping and the nonconducting covering of the latter are gone into and a method of such covering is shown.

Note is taken of automatic stoking, and the author concludes with a summary of necessary preliminaries for the placing in service of a ship's motive power plant.

POWER

Vol. 35 NEW YORK, MARCH 19, 1912 No. 12

DID you ever go into a spick-and-span show power plant? Of course, you were impressed.

But didn't you come away with the main idea that much useless labor was spent in polishing brass work and cleaning white paint? Was not economy and efficiency pushed into the background?

A show plant is suitable for advertising purposes, but it is out of place when used for commercial work, unless enough help is employed to keep it in condition.

If an engineer has to polish useless brass work, he will not have the time necessary to devote to keeping his engines, boilers and auxiliaries in shape. No two ways about that. Might just as well expect him to obtain furnace economy with the firing doors open.

There are power-plant managers who bank more upon appearances than upon results. Beauty is but skin deep, and a boiler with a shining front and fittings may be so coated with scale that economy is out of the question. Don't forget that.

For instance, the "engineer" of a show plant went to a new job. He had kept the bright work polished and the machinery as clean as the proverbial whistle. The superintendent thought that this "engineer" was a "live one" and was sorry to see him go.

Another man came and in about four months he got fired.

Why?

Because the first thing he did was to paint the brass work black and cut out useless work. He devoted his time to the engines and boilers. The superintendent thought he had used paint because he was too lazy to juggle brass polish and a cleaning rag.

But the engines were kept clean and ran smoother than they had with the former engineer. Instead of doing a wiper's work, this engineer put in his time stopping up air leaks in the boiler setting; he also removed over 7000 lb. of scale from the boilers.

A discarded feed-water heater that had not been used in six years was repaired and put in service again.

A comparison of indicator diagrams taken under old and new conditions showed that the new engineer had not been idle.

When this engineer found that he could not do all this useless cleaning and keep his engines and boilers in shape, he chose the lesser of two evils and cut out the brass work. He kept his machines in order and got discharged for doing what an engineer is paid to do.

A show plant was of more importance to the superintendent than well-kept machinery. Polishing rags and floor mops were given preference over the intelligent use of an indicator, or boilers free from scale.

A cheap man could have been hired to do the cleaning; for paying an engineer's wages to do wiper's work is not good business policy. When it comes to choosing between shining brass and economical operating conditions, cut out the glitter and give the engineer a chance to do an engineer's work.

An Interesting Power System

By C. A. Tupper

With sawmill refuse as fuel, steam is furnished to a turbine plant supplying power to the sawmill and is also conveyed through an exposed pipe line 2100 ft. long to a combination high-pressure engine and low-pressure turbine plant. The excess exhaust steam is used for heating.

An interesting combination of two modern steam-turbine plants, one supplied direct by boilers using sawmill refuse as fuel, and the other utilizing exhaust steam from an engine and auxiliaries supplied by the boilers of the first plant, is to be found at Virginia, Minn. Each of these stations, furthermore, is independent of the other, the steam in the latter instance being merely a commodity purchased. A general outline of the system is shown in Fig. 1.

The main generating plant is owned by the Virginia & Rainey Lake Co., a Duluth corporation engaged extensively in logging and transportation. At Virginia there are two large sawmills, located together, with the steam-turbine plant at one end. All wood waste from the mills, after being ground into small pieces, is conveyed with the sawdust (which is collected as shown in Fig. 2) to the boiler room and is fed continuously to the furnaces.

Boilers

There are fourteen 6x18-ft. return-tubular boilers, each of 150 hp., with dutch-oven settings and wood-burning furnaces. Steam from the boilers at 145 lb. pressure is collected in a 10-in. header and passes to the engine room through a 12-in. pipe, from which 5-in. branches lead to the turbines and also to a Murray Corliss mill engine.

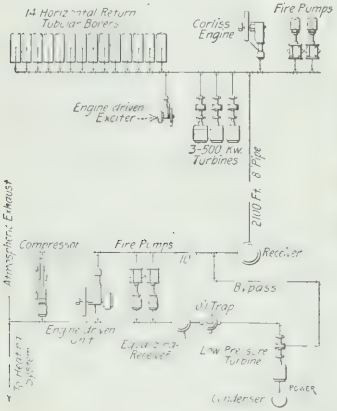


Fig. 1. General Layout of System

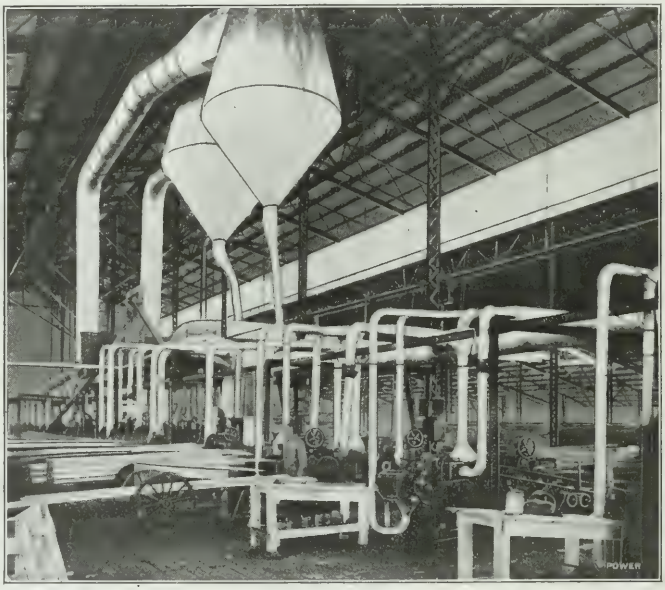


Fig. 2. Showing Method of Collecting Sawdust for Burning Under Boilers

Turbines

The turbines are three in number (see Fig. 3), each coupled to a 500-kw., three-phase, 60-cycle, 600-volt generator. Each turbine exhausts through a 24-in. nozzle to a Tomlinson condenser located directly underneath, and from this the water and air are removed by a rotary engine-driven pump. Injection water is taken from a cold well. The vacuum is maintained at about 28 in., and attached to the condenser head is an automatic vacuum breaker.

One 30-kw. engine-driven and one 35-kw. motor-driven generator furnish excitation current. There is also a 35-kw. motor-generator set for charging four electric yard locomotives.

Steam Distribution

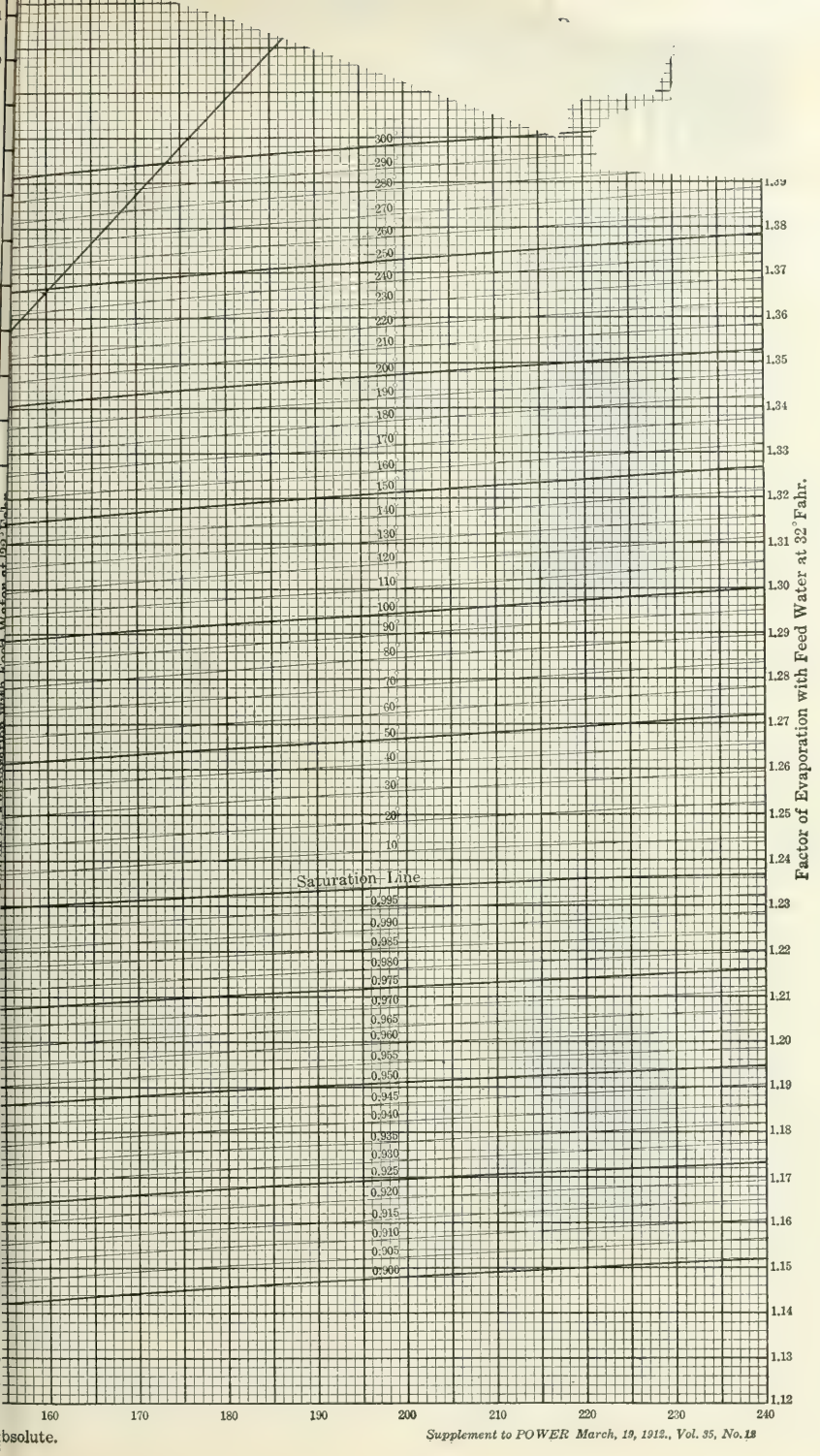
Steam from the boilers of this plant is carried through an 8-in. pipe line 2100 ft. long (see Fig. 4), to the power station of the Virginia Electric Power & Water Co. This pipe rests on rollers supported by wooden posts, to each of which a 2-in. saddle has been strapped and at every 200 ft. there are expansion joints. The pipe is covered with 2-in. magnesia covering inclosed in ¼-in. painted canvas. The line ends in a suitable receiver and the drop in steam pressure over the entire distance does not exceed 3 to 5 per cent. Condensation is cared for by an automatic trap which discharges less than 10 gal. per hour, even in severe winter weather.

From the receiver the live steam passes to a 10-in. header and is distributed to an engine-driven generating set, of 300 kw. capacity, and to various other steam units, including an air compressor, and two fire pumps having a combined delivery of 3000 gal. per minute. The compressor operates the air lift from a well into a 275,000-gal. cistern, from which a steam pump raises the water to an overhead reservoir supplying the city mains.

There is held in reserve the original power unit of the company, consisting of two boilers and a George H. Corliss engine built over 40 years ago, which is belted to a 200-kw. generator.

Heating the Plant

The exhaust from all of the units is collected in a low-pressure line which, besides serving in winter to heat the power plant, the company's offices, two blocks distant, and other buildings in the vicinity, is used in a low-pressure Allis-Chalmers turbine. For the last-named purpose the steam passes first into a receiver, through an equalizing valve, and then, through an oil separator, at 16½ lb. absolute, into the turbine.



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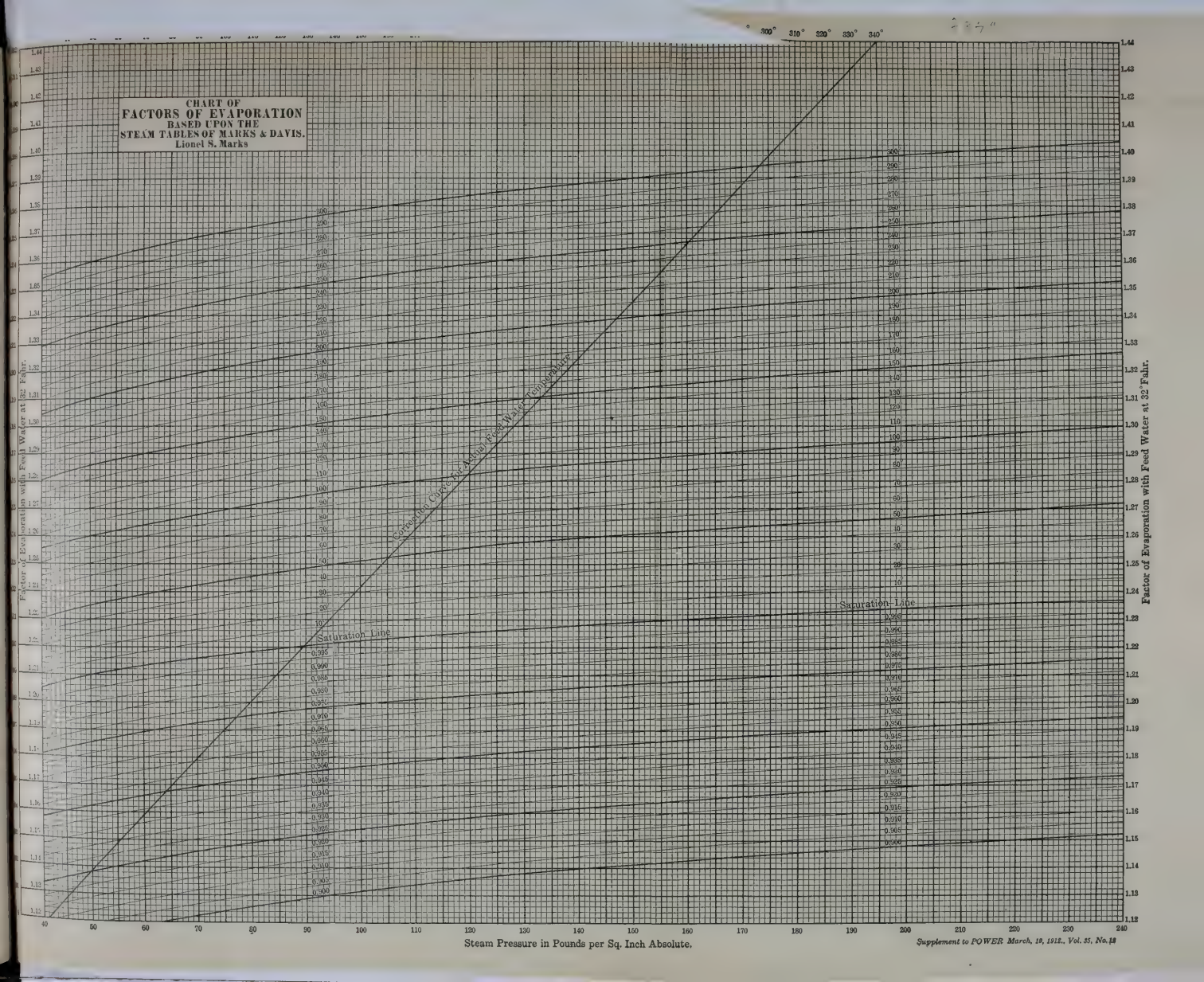


CHART OF
FACTORS OF EVAPORATION
BASED UPON THE
STEAM TABLES OF MARKS & DAVIS.
Lionel S. Marks
Corrected for Correct Actual Feed-Water Temperature
Saturation Line
Saturation Line
Factor of Evaporation with Feed Water at 32° Fahr.
Factor of Evaporation with Feed Water at 32° Fahr.
Steam Pressure in Pounds per Sq. Inch Absolute.

This machine is coupled direct to a 375-kw. alternating-current generator running at 3600 r.p.m., and operating in parallel with the engine-driven unit.

From the live-steam header there is a 2½-in. bypass by means of which high-pressure steam is automatically admitted when needed to the intermediate stage of the turbine. The pressure of this live steam varies from 145 to 80 lb., according to the demands of the sawmill power plant upon its boilers. The high-pressure connection is under control of the governor, so that, should the supply of low-pressure steam be inadequate, live steam will be admitted automatically to the turbine, this steam being throttled in its passage through the governor inlet valve.

The air compressor and water pump are run continuously during the day and these units, with the condenser pump, supply enough exhaust steam for ordinary day loads. When the turbine load and the heating system do not call for the full quantity of steam exhausted, a relief valve in the exhaust receiver opens to the atmosphere; while, on the other hand, the heating system is insured of its full required supply in winter by a differential setting of the valves in the low-pressure system.

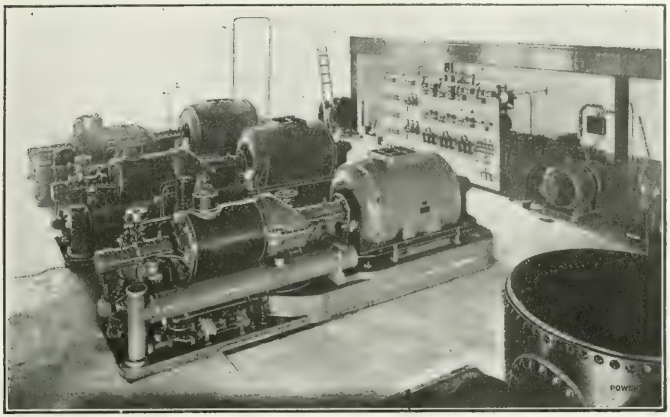


FIG. 3. THREE 500-KW. TURBO-GENERATORS

The turbine is kept going continuously and the engine-driven unit comes in on the late afternoon and evening load.

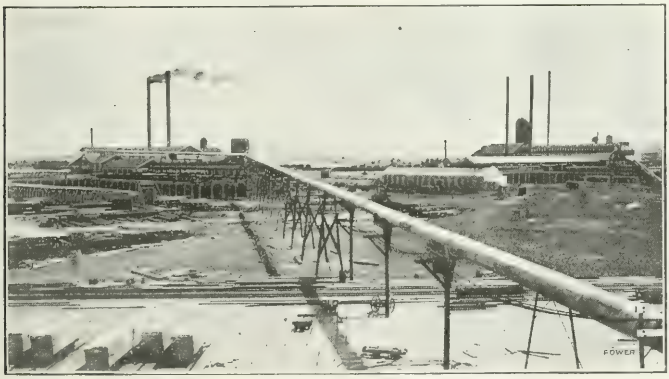


FIG. 4. PIPE LINE CARRYING STEAM 2100 FT.

Air Compressor Efficiency*

The development of compressors prior to the electrical era proceeded hand in hand with that of the steam engine, and its development has been marked by a gradual increase of rotary speed in order to keep pace, first with the steam engine and more recently with the electric motor. The latest development—that of the turbo-compressor—is one in which steam and electrical prime movers are equally interested, and very keen rivals.

Present-day methods of overcoming difficulties due to heating of the air during compression and of increasing the thermal efficiency of compressors are: (1) To water jacket the air cylinder and ports as thoroughly as their mechanical construction will allow. (2) To compress in stages if the final pressure required is so high as to make efficient lubrication difficult, the danger of spontaneous ignition of the lubricant (and frequently of entrained coal dust) imminent, or the power required for compression in one cylinder excessive.

In the days of slow-running machines, the valves were very simple, but as rotary speeds advanced the crude valves were found to be unsatisfactory, their weight alone being sufficient to cause the final pressure within the cylinder to rise considerably above that in the delivery main; hence it was recognized that for higher speeds improved valves were required. Present-day valves have resulted through development along the following lines: reduction of weight, reduction of lift, introduction of air buffers, use of auxiliary valve-gear, use of mechanically controlled valves, use of positively worked valves, introduction of unloaded valves and use of so called weightless valves.

Reduction of clearance volume, as time went on, was thought to be a matter of importance, and this gave Prof. Riedler an opening for the introduction of his mechanically controlled automatic valves. These were mounted upon the cylinder covers themselves, and thus reduced the clearance volumes to a minimum. The valve is, for moderate rotary speeds, an ideal one, and it is largely made use of even today on compressors of large size.

With the Riedler valve, compressor speeds advanced sufficiently to induce electrical engineers to advocate their direct driving by electric motors. For large units, the flywheel type of motor was usual, and its expense led to a further speeding up of the compressor. Thus, speeds were soon reached which made the elimination of extra valve-gear necessary; automatic valves again became popular, and extensive use was made of air buffers. But it was soon discovered that the air buffer not only acted to check the opening motion of the valve as desired, but it also hindered it in closing and thus led to its hammering on the valve seat. Buffers, therefore, gave way to the so called weightless type of valve, of which there are now innumerable varieties.

Turbo-compressors expose greater surfaces suitable for water jacketing than reciprocating compressors offer, and while being compressed in turbo-machines the air is distributed along passages and channels of smaller mean depth than those met with in the older type of

*Excerpts from paper read before the Rugby Engineering Society by B. M. Woodhouse.

machine. It appears, therefore, at first sight, that thorough cooling during compression should be an easy matter. Results scarcely confirm such expectation, chiefly because of two peculiarities of turbo-compressors, namely:

1. The amount of heat to be dissipated is considerably more than that due to adiabatic compression, as the mechanical energy lost through internal air leakage, unavoidable eddy currents, air impact, and air friction reappears as heat energy stored mostly in the air itself. Heat is also generated through the resistance opposed by the air to the motion of the rotors.

2. The temperature rise of the air is gradual; consequently the air temperature in the early stages of the compressor is too little different from that of the atmosphere to enable rapid dissipation through the necessarily somewhat thick cast-iron walls of the housing.

It can be said, Mr. Woodhouse continued, that since 1882 the rotary speed of compressors has gradually increased from 12 to 1200 r.p.m. in the case of reciprocating machines, and to 4000 r.p.m., and even more, in the case of turbo-compressors. This change has been accompanied in the case of reciprocating compressors by continual variation of valve design.

Heating of the air during compression is a source of waste of energy. A minimum of work is required to accomplish compression when the rise of pressure takes place isothermally, and, although with reciprocating dry compressors, this ideal is unattainable, it is still one after which the designer must aspire.

The author adds that if each stage of a compound reciprocating air compressor is considered as a distinct unit, it is safe to say that, in practice, compression takes place almost adiabatically. This is on account of the extreme difficulty of extracting from the air the heat generated during compression while the air is within the cylinder.

Briefly, the object of Mr. Woodhouse is to awaken interest (1) in air-valve design, as upon this detail the mechanical success of the air end of the unit is, to a large extent, dependent; (2) in the cooling of air during compression, because high thermal efficiency is certainly unattainable when water jackets only are used; (3) in the importance of volumetric efficiency, on account of the great effect it has upon the commercial efficiency of air-compressing machinery.

In his opinion, compressors can be run successfully and with good commercial efficiency at any speed suitable for reciprocating machinery of similar construction, provided always that the valves are of appropriate design, and that the air ports are constructed in such a way as to avoid excessive wire-drawing or too voluminous clearance spaces.

Chart of Factors of Evaporation

By Prof. Lionel S. Marks

In order to obtain a fair comparison of the performance of different steam boilers, it is necessary to measure their performance by some common scale. If we were to compare the lengths of several rods, we could do it either (1) by choosing one as a standard and expressing the lengths of all the others in terms of the length of that one; or (2) we could choose some arbitrary length (such as the foot) as unit of length and could then express the lengths of all the other rods in terms of that arbitrary unit. The latter procedure is followed in steam-boiler practice.

A steam boiler takes in heat from some external source, generally from a coal fire, and utilizes it for the evaporation of water. The efficiency of the boiler is most accurately measured by the percentage of the available external heat that it takes in. The usual method of measuring this amount of heat is by determining the weight of water evaporated per pound of coal burned under the boiler.

This method of measurement does not, however, permit a direct comparison between two boilers both of which are burning the same kind of coal. If, for example, one boiler takes in feed water at 210 deg. F. and generates steam at 90 lb. absolute and of a quality 0.98, and the other boiler takes in its feed water at 76 deg. and generates steam at 170 lb. absolute, superheat 150 deg., there will obviously be a considerable difference between the heat supplies per pound of steam generated in the two boilers. Actually, for the conditions just stated, the heat supplies would be in the ratio of 8 to 10, so that the evaporations per pound of coal in the two boilers would have to be in the ratio of 10 to 8 in order to get equal efficiencies from the two boilers.

In order to permit a true comparison of the efficiency of the boilers, it has become the general practice to reduce the actual weight of steam evaporated in the boiler to that which would have been evaporated, with the same amount of heat absorbed, if the feed water had gone to the boiler at 212 deg. and had been converted into dry and saturated steam at that same temperature.

According to the steam tables of Marks and Davis, the amount of heat required to evaporate 1 lb. of water under those conditions is 970.4 B.t.u. To find what weight of steam would have been evaporated in any given boiler with the actual heat that has gone into that boiler but with the assumed standard conditions of evaporation "from and at 212 deg. F.," it is necessary to find the actual heat supply per pound of steam formed in the boiler and to divide it by the heat supply (970.4 B.t.u.) per pound of steam in the standard boiler. This ratio is called the "factor of evaporation." If the actual weight of steam evaporated is multiplied by the factor of evaporation, we get the "equivalent evaporation" of the boiler; a quantity which permits a direct comparison between different boilers using the same kind of coal.

The accompanying chart permits the immediate finding of the factor of evaporation corresponding to any given condition of steam generation. The absolute steam pressure is plotted horizontally. The curves below the line marked "saturation line" are for wet steam, the quality (dryness factor) being marked on each curve. Above the saturation line, the curves are for superheated steam of the degree of superheat shown by the figures. The vertical scales on both sides of the chart give the corresponding factors of evaporation, on the assumption that the feed-water temperature is 32 deg. In practice, the feed-water temperature is always greater than 32 deg. F., and to correct for the actual temperature, something must be subtracted from the factor of evaporation as taken from the curves. The diagonal line permits of the immediate determination of this correction. The top horizontal scale is for feed-water temperature. The outside vertical scale on the left of the chart gives the corresponding correction for the factor of evaporation.

As an example of the use of this chart, we may take the conditions given earlier, namely, steam at 170 lb. absolute pressure, superheat 150 deg., with feed water at 76 deg. Starting with 170 lb. on the lower horizontal scale, and following vertically upward to the curve marked 150 deg., the intersection is seen to be on the horizontal line corresponding to the factor of evaporation 1.317. This, however, assumes a feed-water temperature of 32 deg.; the actual temperature is 76 deg. To correct for this, start from 76 deg. on the top horizontal scale and follow vertically down to the correction curve; the intersection is on the horizontal line corresponding to the correction 0.045 as given on the vertical scale on the extreme left. The actual factor of evaporation is consequently

$$1.317 - 0.045 = 1.272.$$

A patent was recently granted to E. A. Kelsey, Mt. Vernon, N. Y., for fitting valves to their seats by pressing one upon the other so that the imperfections in the shape of each will be reversely reproduced in the other, and guiding the valve to seat it in the same position in the seat in which it was fitted.

During 1911, the exports of British coal amounted to 64,599,266 long tons.

Notes on the Use of Belt Conveyers

By John J. Ridgway

Practical considerations covering the most efficient drives, feeds, arrangement of chutes, capacities and speed. The care of belt conveyers is also touched upon.

With level conveyers it makes very little difference whether the drive is at the head or tail, but when elevated a head-pulley drive should be used wherever possible, because driving from the tail brings the slack belt on the upper or load-carrying side to the detriment of the traction of the driving pulley and can only be compensated for by increasing the tension, which is undesirable.

With an intermediate drive where two snub pulleys are used in connection with the driving pulley, the greatest objection is the practical impossibility of getting the belt perfectly clean and especially in abrasive materials where the pieces are angular and often imbedded in the belt; this character of drive intensifies the injury resulting from the use of snub pulleys. These are always a detriment owing to the working side of the belt, when in its greatest tension, being forced against the face of the pulley.

It is too often the custom to minimize the head or driving pulley and increase the arc of contact by using the snub pulley. This is very bad practice, and in most cases can be eliminated by increasing the diameter of the driving pulley and making a long lead to the first return idler.

That type of troughing idler should be used which embodies the greatest simplicity in construction, is the most easily lubricated and does the least detriment to the belt.

The three-pulley setting—the center pulley horizontal and the two side pulleys at varying angles—is the simplest, cheapest, most easily lubricated and most efficient. In the writer's judgment, when the pulleys are in line the action of the horizontal pulley at the point of meeting with the side or angle pulley often produces the effect of a pair of shears; this can be eliminated, however, by offsetting the pulley.

Guide idlers should always be avoided, if possible. Their object is to control the shearing of the belt which, by reason of its not conforming to the outline of the idlers, and through imperfect contact or traction, has a tendency to run to that side where the traction is greatest, and if not controlled by these guide idlers would tend to run off.

This is so much the case that one often sees arguments used by belt manufacturers that they make special provision to protect the edge of the belt by more than the usual amount of cover or pad and draw attention to the perfection of attachment whereby this cover is vulcanized to the belt.

Traction versus Tension

The subject of traction ought to receive the greatest consideration, because a fabric when loose is not as easily cut as when in tension.

In many cases an undue amount of tension is placed upon conveyer belts; some due to lack of thought on the engineer's part, to penny-wise and pound-foolish practice, and to the necessity for employing tension in order to make the belt trough run approximately true.

The diameter of the head pulley is often reduced, thereby increasing the necessary tension; this practice saves a dollar in initial cost but may cost fifty dollars in wear and tear on the conveyer belt. Excess power due to tension or any other cause carries with it three detriments: First, the initial cost to furnish the power; the fixed charge for operation, and the wear and tear on belting and machinery occasioned by the extreme tension.

Feeds

Where material is fed to a belt these chutes should be so constructed and at such angles as to deliver the material at approximately the same speed at which the belt is traveling in order to produce the least possible abrasion. Moreover, the edge of the chute should be turned up slightly, to prevent the direct impact of the material on the belt. Conveyer belts are intended to convey, and not for impeding the velocity of the material; and this should always be kept in mind.

Sometimes it is desirable to feed a belt from a succession of bin gates with feeding chutes attached, in which case the principle underlying the initial feed chute should be embodied. It is very undesirable, although often done, to feed from two or more of these chutes at the same time; this is apt to overload the belt, and produce abrasion due to the discharge from a preceding chute being scraped and ground into the belt by its interference with a succeeding chute. Where multiple feed must be used mechanical control should be employed and not the usual type of gravity feed, which is always susceptible of the foregoing objection.

Chutes

Under this general heading are embodied initial feeding chutes, intermediate, transfer and tripper chutes, the latter often including a three-way chute. The great trouble in connection with all chutes is the disposition to minimize space to the detriment of good engineering practice and injury thereby to the belt. The latter being the most expensive item in connection with the conveyer, is the one which should receive foremost consideration, and the inevitable wear and tear thereof minimized.

In all chutes, whether direct or transfer, the material should be delivered to the center of the belt and the wings of the chutes should be lifting and set at an angle to the travel of the belt so that the material shall continually clear itself and not jam and grind under the edge of these wings.

Elevating

The subject of elevating material is one which is dependent on various contingencies and is controlled by a number of factors which must be individually considered, but the general principle is this: There is a relation between the traction of the material in connection with its angle of rest and velocity, that determines the angle of elevation.

These conditions are not always sufficiently considered, especially when they are complicated by various sizes of material, including small and large lumps, the percentage of each, the character of the feed, etc.

The question of intermittent or continuous feed is one which can be eliminated under almost all conditions because a continuous feed is more a question of theory than of practice.

Capacities

The disposition to figure the theoretical for the practical is too often the cause of disappointment, and it would seem hardly necessary to mention this if it were not overlooked so often in practice.

To find the capacity of a conveyer belt it is best to make a diagram of the troughing idler, measure 2 inches down from the edge of the belt, draw a straight line connecting these two points, figure the area therein, and calculate in tons, of whatever may be the particular character of material to be handled; discount this one-third and the result will as nearly approach the average maximum as one will get in practice.

Speed

The speed at which a conveyer belt can be run depends upon several factors, the character of the belt, the class of material and the spacing of the troughing

idlers. Originally, belts were run at speeds as high as 1000 feet a minute, but now the tendency seems to be toward that of slow speed, to the injury of clean deliveries, and consequent wear and tear to the belt at delivery and transfer chutes.

Deliveries

Where it is desirable that there should be the least possible breakage of material and where the distance from the conveyer to the bottom of the storage bin is 30, 40 or 50 feet, fish ladders can be used. These consist of boards or plates placed at angles to correspond with the material handled. Through this the material takes a zigzag course; or a center support is provided having a chute like a spiral staircase with a lip 1 or 2 inches high to prevent the material from being thrown off by centrifugal force. This carries the material to the bottom, spilling over the edge and building on itself until the bin is full.

Breakage

To eliminate breakage is not so much a question of speed as it is the character and design of the receiving and delivery chutes together with the general nature of the installation. Where conveyers are run in series each succeeding conveyer ought to be stepped up at least 5 per cent. in speed so that there shall never be any choking of the material in the transfer.

Trippers

Trippers, stationary or movable, should be used only where it is not possible to employ a mechanism that can be thrown into or out of operation, utilizing a counterweight to make this practical and looping the belt on the underside to give the necessary go and come and taking up the slack when the tripper is not in operation. All trippers embody the use of a snub pulley and they largely increase the tension, which is undesirable.

Automatic reversing trippers are complicated and expensive, and the writer has known only very few cases where the conditions made it possible to employ those embodying the automatic, reversing, continuously moving idea. In nine cases out of ten they are shifted from place to place, locked to the rail, and the automatic reversing feature is surplusage.

Cleaning a Belt

Sufficient care is not always taken to keep the belt and conveyer clean. This is frequently illustrated in plants where care is taken and the belts operate year after year giving satisfactory service, and a legitimate return in value or service rendered. The belt is relieved of the inevitable wear and tear contingent on the thoughtless, shiftless manner in which belt conveyers are frequently handled.

Decking

It is absolutely necessary to protect the lower line of belting from dust, grit and dirt that may fall upon it, for if any falls through on this lower line and goes on the pulley side of the belt it soon wears off the thin protective covering, bares the fabric and absorbs moisture.

Accidents often occur which are entirely avoidable, as, for instance, those coming from or originating in the initial feed, which in most cases can be provided for by a grating or screen of iron bars to catch any material liable to injure the belt.

Also damage occurs frequently through the careless use of the hoe, bar or shovel in cleaning out transfer chutes. Such instruments ought to be attached by chains or otherwise so that they cannot drop or catch in the belt, and before the power can be shut off, do almost irreparable injury.

Care should be taken in putting on a new belt to see that everything leads fair and true; for a set in a new belt is almost impossible to correct afterward.

Squaring the Ends

After a belt has been strung care should be taken before it is put in tension to see that it runs and lies true on the head, tail and upper and lower idlers, also through the stationary or movable trippers if such are in use.

A square should be placed on the belt, and the latter marked, using the long leg of the square along the edge of the belt.

Lacing or Fastening

In lacing a belt the edges should coincide and the middle of the belt should be fastened first; then put on the two outside fasteners (if a metal fastener be used), using one rivet on each side of each of the three fasteners. Tail the rivets from the joint so that the joints will draw together, and drive the rivets alternately, first on one side then on the other, opposite each other.

Starting and Stopping

Much harm is done by the thoughtlessness of those in charge of belt conveyers by not running their machines at full speed before they begin to feed material on them and also, especially at 12 and 6 o'clock, in the hurry to get away. They stop the machines too soon after the feed has ceased, and before the laggards or lumps which often roll back —advancing two steps and retreating one —have had time to be delivered.

This faulty method of starting and stopping is occasioned by the material dribbling over the head pulleys instead of being projected from them, catching in the transfer and other chutes. Although not a part of the engineering, this is something which can hardly be overlooked in their operation.

Conclusion

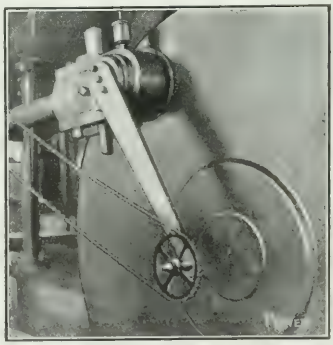
The abuse to which belt conveyers are so often submitted is on a par with the way the average human treats himself. The detriments that are insidious do not make themselves known in a smash-up or a breakdown, but they are nevertheless continuous, and eventually result in destroying the constitution of the man, the usefulness of the mechanism, and are the things which are so often disregarded.

In no type of machinery is it more necessary that constant care and common sense be employed than in the use of belt conveyers.

Peculiar Sprocket Wheel Arrangement

The sprocket wheel operating a telltale on a hoisting engine should be so placed as to be easily accessible in order to care for it and the sprocket chain.

There have been cases where the chain has come off the wheel and, running on the drum shaft, still rotate the telltale indicator, but behind its time. This condition in one instance resulted in wrecking a train of coal cars which were being



Sprocket Wheel Attached to Crank-pin by an Arm

hauled up a slope by running full speed into the foot of the shaft.

On one engine the sprocket wheel was attached to a pin that was secured to the end of an arm which was bolted to the outer end of the crank pin, as shown in the accompanying illustration. The chain led to the indicator dial as shown. It is necessary to have the center of the sprocket wheel in line with the center of the crankshaft in order to insure true running.

What a Candidate for a Second Class License in Massachusetts Has to Know

By L. W. Chadwick

The following questions were asked an applicant for a second-class license in Massachusetts which limits the holder to having charge of 150 engine horsepower or less. However, he may operate a first-class plant under a chief engineer.

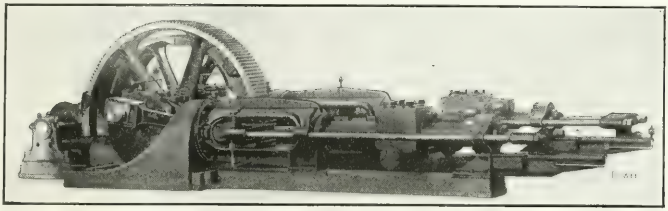
The applicant has made two attempts to get a second-class license within the last six months, and the following questions were repeated to the writer as being those asked by the examiners:

1. What is meant by horsepower in reference to a steam engine?
2. How do you figure the horsepower of an engine?
3. Give an example.
4. What is an indicator?
5. Describe an indicator.
6. What is it for?
7. Draw a good diagram from a single-eccentric Corliss engine.
8. How would you know whether it was from the high- or the low-pressure cylinder?
9. How late can a single-eccentric Corliss engine cut off?
10. Why not later?
11. Given the dimensions of a quadruple-riveted double butt-strap joint, find the efficiency of the joint.
12. Given the area to be braced, pressure carried, diameter and thickness of the shell, find the number of through braces 1 in. in diameter.
13. What parts of a locomotive boiler are braced and why?
14. Describe how each part is braced.
15. Given the dimensions of a water leg, the thickness of plate, pressure to be carried and size of stay-bolts, find how many are required.
16. Is grease detrimental to a boiler; if so, in what way or ways?
17. Where would you most expect to find a bag in a return-tubular boiler?
18. If a bag occurred in a girth seam, how would you patch it?
19. Is a bag dangerous; if so, why?
20. If a boiler has started to pit, what would you do to help stop it?
21. Describe the operation of an independent jet condenser. What is the office of the air pump?
22. Can such a condenser become dangerous to the engine? If so, in what way?
23. Why is scale in a boiler dangerous?
24. If you were forcing a battery of boilers, how could you tell by looking at the glass if one glass or column connection was plugged?
25. If, when you cut out a boiler by closing the stop valve, the pressure drops to zero (gage) and the water surges in the glass, what causes it to do so?
26. Given the number of square feet of heating surface in a boiler, how many square feet of grate surface are required for the same boiler?
27. If you found a bad lap crack, how would you repair it?
28. Where is the fusible plug in an Almy boiler?
29. In figuring the stress on a longitudinal seam, why is the radius used?
30. What is the use of an auxiliary piston in a steam pump?
31. How is it possible for a pump to work against a pressure greater than the steam pressure?
32. Draw a diagram and explain how to find the stress on 1 in. of a longitudinal seam. The same on a girth seam.
33. Given the dimensions, find the efficiency of a double butt-strap, double-riveted joint.
34. What is a double "D" valve and where is it used?
35. How is wood packing used and kept in place on a condenser with a bucket piston on the pump?
36. Given the number of square inches, thickness of plate, pressure to be carried, size of hollow stay-bolt, size of hole and stay-bolt, how many are required in the water leg of a locomotive type of boiler?
37. Find the pitch of rivets in a boiler. How do you find the size of them?
38. The safety valve on a boiler plays out and you get a new one; how would you know whether it was all right?
39. Would you recommend an open or a closed heater for factory work?
40. What is a horsepower constant?
41. If you take up on the spring of an automatic governor to speed up the engine and the latter races, what is wrong?
42. If an engine delivering 150 hp. suddenly drops to 140 hp., what is wrong and how may it be remedied?
43. If the steam pressure drops on a condensing engine, what can you do to help out until the steam pressure is up again?
44. How would you get a later cutoff on a single-eccentric Corliss engine?

5000 Pound Pressure Pump

Of more than ordinary interest is the large duplex, outside-packed, plunger type of power pumping engine shown in the illustration. This machine has four 2⅛-in. plungers, with a common stroke of 18 in., and at 47 r.p.m. of the crankshaft, is capable of delivering 50 gal. per minute against a working pressure of 5000 lb. per square inch. Two of these pumps were recently built for the Chase Rolling Mills, Waterbury, Conn., by the Deane Steam Pump Co., Holyoke, Mass.

The elimination of pressure joints in a machine of this type is a consideration of primary importance; consequently, in these machines, each cylinder is made integral with its valve chamber from a steel billet. The two chambers for the reception of the plungers and all internal water passages, subject to discharge pressure, are drilled from the solid metal. The valve service is of tool steel and each valve is separately accessible from above through its individual handhole opening; thus greatly facilitating the refacing of valves and seats.



General View of High-pressure Pump

The plungers being of small diameter, the stroke comparatively long, and the net plunger load high, special attention has been directed to the prevention of plunger deflection. The weight of the plungers, crossheads and side rods is supported at both ends of the cylinder on adjustable shoes, and in addition the alignment of the side rods is maintained by guides on the yoke and on the outer end of the cylinders.

The gearing is machine-cut from the solid blank, and the crankshaft, which operates in main bearings of the quarter-box type, is an openhearth steel forging. Annealed-steel castings are used for the disks which are integral with the pins, and the connecting-rods are of the solid-end type, of machine steel, fitted with phosphor-bronze bearing boxes and made adjustable for wear at both ends. The crossheads are fitted with adjustable shoes and are operated in bored guides in the yokes. Drippings of lubricating oil and stuffing-box leakage on the foundation are prevented by deep retaining flanges and pans, made integral with the machine.

Schedule of Flanges, Flanged Fittings

In the June 27, 1911, issue was printed a schedule of flanged fittings arranged by the committee on standardization of the American Society of Mechanical Engineers, acting in conjunction with a similar committee from the National Association of Master Steam and Hot Water Fitters.

Since this earlier report of the committees, however, the schedule has been revised and considerably amplified, and in its present form, as herein given, has been recommended officially by the American Society of Mechanical Engineers, and adopted by the National Association of Master Steam and Hot-Water Fitters. Furthermore, at the annual meeting of the American Society of Heating and Ventilating Engineers the new schedule was recommended for use by its members.

The personnel of the committees on standardization was as follows:

American Society of Mechanical Engineers: H. G. Stott, John H. Sparrow, William Schwanhausser, Walter M. McFarland, Albert C. Ashton.

National Association of Master Steam and Hot Water Fitters: William J. Baldwin, Jr., N. Loring Danforth, William T. English, William P. Kirk, Thomas B. Cryer, Edward B. Denny, William H. Oakes.

Explanatory Notes

The following explanatory notes will be found useful in connection with the schedule:

1. Standard or extra-heavy reducing elbows carry the same dimensions center to face as the regular elbows of the largest straight size.

2. Standard or extra-heavy tees, crosses and laterals, reducing on run, carry the same dimensions face to face as the largest straight size.

3. If flanged fittings for lower working pressures than 125 lb. are made, they shall conform in all dimensions, except in thickness of shell, to this standard, and shall have the guaranteed working pressure cast on each fitting. Flanges for these fittings must be of standard dimensions.

4. Where long-turn fittings are specified, it has reference only to elbows, which are made in two center to face dimensions, to be known as "elbows" and "long-turn" elbows, the latter being used only when so specified.

5. All standard-weight fittings must be guaranteed for 125 lb. and extra-heavy fittings for 250 lb. working pressure, and each fitting must have some mark cast on it indicating the maker and the guaranteed working steam pressure.

6. All extra-heavy fittings and flanges to have a raised surface $\frac{1}{16}$ in. high inside of the bolt holes for the gasket.

Standard-weight fittings and flanges to be plain faced.

Bolts to be $\frac{1}{8}$ in. smaller in diameter than the bolt holes.

Bolt holes should straddle the center lines.

7. Size of all fittings scheduled indicates the inside diameter of the ports. For the outside diameter of pipe use the corresponding size of the inside diameter fittings.

8. The face to face dimension of a reducer, either straight or eccentric, shall be equal to the diameter of the larger flange.

9. Square head bolts with hexagonal nuts are recommended.

10. Twin ells, double branch ells, side outlet ells, side outlet tees and four-way tees, whether straight sizes or reducing, carry the same dimensions center to face and face to face as the regular ells and tees.

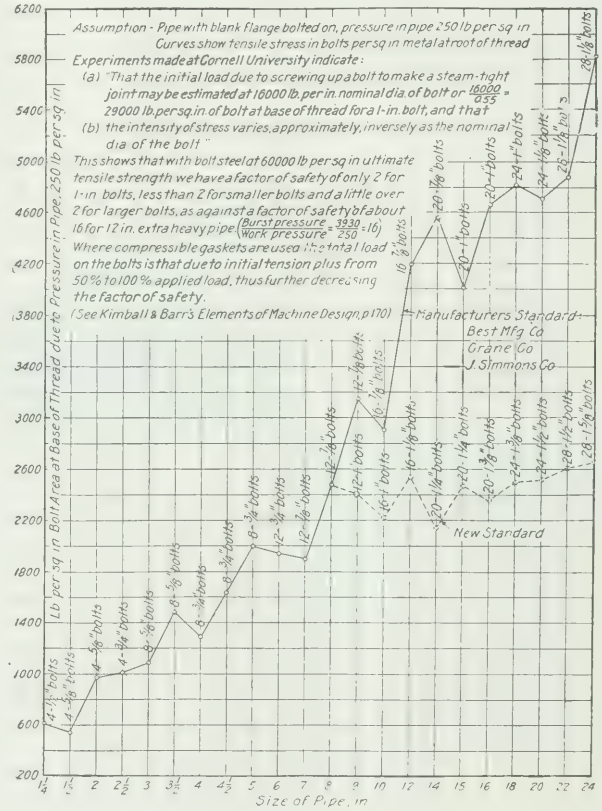
11. Bull-head tees or tees increasing on outlet will have the same center to face and face to face dimensions as a straight fitting of the size of the outlet.

12. Up to and including the 4-in. size, center to face and face to face dimensions of reducing fittings will be the same as that of a straight fitting of the larger opening.

13. Pipe sizes 14 in. and over refer to outside diameter.

Stresses in Bolts

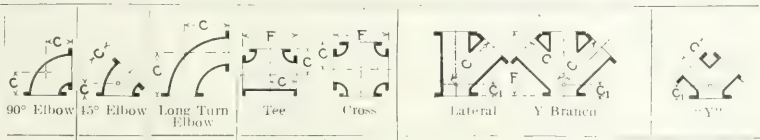
In connection with the report of the standardization committee, the February issue of the *Journal* of the American Society of Mechanical Engineers contains the accompanying chart, showing the stresses in the bolts at the base of the thread due to a pressure in the pipe of 250 lb. per square inch. The chart shows the extent to which these stresses increase with the sizes of the pipe in the Manufacturers' Standard, and the dotted lines show the departure made from the latter in order to keep the stresses down to what is considered a safe limit.


Assumption - Pipe with blank flange bolted on, pressure in pipe 250 lb per sq in
Curves show tensile stress in bolts per sq in metal at root of thread
Experiments made at Cornell University indicate:
(a) "That the initial load due to screwing up a bolt to make a steam-tight joint may be estimated at 16000 lb. per in. nominal dia. of bolt or 16000/455 = 29000 lb. per sq. in. of bolt at base of thread for a 1-in. bolt, and that
(b) the intensity of stress varies, approximately, inversely as the nominal dia. of the bolt"
This shows that with bolt steel at 60000 lb per sq in ultimate tensile strength we have a factor of safety of only 2 for 1-in. bolts, less than 2 for smaller bolts and a little over 2 for larger bolts, as against a factor of safety of about 16 for 12 in. extra heavy pipe (Burst pressure / Work pressure = 3930/250 = 16)
Where compressible gaskets are used the total load on the bolts is that due to initial tension plus from 50% to 100% applied load, thus further decreasing the factor of safety.
(See Kimball & Barr's Elements of Machine Design, p 170)
Manufacturers' Standard
Best Mfg Co
Crane Co
J. Simmons Co
New Standard
Lb. per sq in Bolt Area at Base of Thread due to Pressure in Pipe, 250 lb per sq in
Size of Pipe, in

Stress at Base of Thread in Bolts for Different Sizes of Pipe

SCHEDULE OF FLANGES AND FLANGED FITTINGS

Standard Weight Flanged Fittings



Size, Inches	All Fittings and Flanges: Diameter of Flange	All Fittings and Flanges: Thickness of Flange	All Fittings and Flanges: Number of Bolts	All Fittings and Flanges: Diameter of Bolt Circle	All Fittings and Flanges: Diameter of Bolt Holes	All Fittings and Flanges: Size of Bolts	90° Elbow: Center to Face "C"	45° Elbow: Center to Face "C"	Long Turn Elbow: Center to Face "C"	Tee: Center to Face "C"	Tee: Face to Face "F"	Lateral: Center to Face "C"	Lateral: Center to Face on Short End "C_1"	Lateral: Center to Face of Outlets	Y Branch: Face to Face "F"	Y Branch: Center to Face "C"	Y Branch: Center to Face Short End "C_1"
1	4	7/16	4	3	5/8	7/16	3½	2	5½	3½	7	6	2		8	3½	2
1¼	4½	½	4	3⅜	5/8	7/16	3¾	2	6	3¾	7½	6¼	2¼		8½	3¼	2¼
1½	5	9/16	4	3⅞	⅝	½	4	2¼	6½	4	8	6¼	2¼		9½	4	2¼
2	6	⅝	4	4¾	¾	⅝	4½	2½	7	1½	9	8	2½		10½	4½	2½
2½	7	11/16	4	5½	¾	⅝	5	2¾	7½	5	10	9½	2½		12	5	2½
3	7½	¾	4	6	¾	⅝	5½	3	8	5½	11	10	3		13	5½	3
3½	8½	13/16	4	7	¾	⅝	6	3½	9	6	12	11½	3		14½	6	3
4	9	⅞	8	7½	¾	¾	6½	4	10	6½	13	12	3		15	6½	3
4½	9½	15/16	8	7¼	⅞	¾	7	4½	11	7	14	12½	3	11¾	15½	7	3
5	10	⅞	8	8½	⅞	¾	7½	4½	12	7½	15	13½	3½	12½	17	7½	3½
6	11	1	8	9½	⅞	¾	8	5	13	8	16	14½	3½	13	18	8	3½
7	12½	1 1/16	8	10¾	⅞	¾	8½	5½	14½	8½	17	16½	4	13¾	20½	8½	4
8	13¾	1⅛	8	11¾	⅞	¾	9	6	16	9	18	17½	4½	14¼	22	9	4½
9	15	1 3/16	12	13¼	⅞	¾	10	6½	18	10	20	19½	4½	17¼	24	10	4½
10	16	1¼	12	14¼	1	⅞	11	7	20	11	22	20½	5	18½	25½	11	5
12	19	1 5/16	12	17	1	⅞	12	7½	22	12	24	21½	5½	20	30	12	5½
14	21	1⅜	14	18¾	1⅛	1	14	7½	24	14	28	27	6	21½	33	14	6
15	22¼	1 7/16	16	20	1⅛	1	14½	8	26	14½	29	28½	6	22¾	34½	14½	6
16	23½	1 7/16	16	21¼	1⅛	1	15	8	28	15	30	30	6½	22¾	36½	15	6½
18	25	1 9/16	16	22¼	1¼	1¼	16½	8½	30	16½	33	32	7	24¼	39	16½	7
20	27½	1 11/16	20	25	1¼	1¼	18	9½	32	18	36	35	8	25¼	43	18	8
22	29½	1¾	20	27¼	1¼	1¼	20	10	34	20	40	37½	8½	27½	46	20	8½
24	32	1 13/16	20	29½	1⅜	1⅜	22	11	36	22	44	40½	9	28½	49½	22	9
26	34½	2	24	31¾	1⅜	1⅜	23	13	39	23	46	43½	9½	30¾	53	23	9½
28	36¾	2 1/16	28	34	1⅜	1½	24	14	42	24	48	46½	10½	33	57	24	10½
30	38¾	2⅛	28	36	1½	1⅜	25	15	15	25	50	49½	11	35½	60½	25	11

Extra Heavy Flanged Fittings

1	4½	11/16	4	3¾	⅝	½	4½	2½	5½	4½	8½	7½	2⅝	.	9½	4½	2½
1¼	5	¾	4	3¾	⅝	½	4½	2½	6	4½	8½	7½	2⅝		9½	4½	2⅝
1½	6	13/16	4	4½	¾	⅝	4½	2½	6½	4½	9	8½	2⅝		11	4½	2½
2	6½	⅞	4	5	¾	⅝	5	3	7	5	10	9½	2½		12	5	2½
2½	7½	1	4	5⅞	⅞	¾	5½	3¾	7½	5½	11	10½	2½		13	5½	2½
3	8½	1⅛	8	6½	⅞	¾	6	3½	8	6	12	11½	3		14½	6	3
3½	9	1 1/16	8	7¼	⅞	¾	6½	4	9	6½	13	12½	3		15½	6½	3
4	10	1¼	8	7¾	⅞	¾	7	4½	10	7	14	13½	3		16½	7	3
4½	10½	1 5/16	8	8½	⅞	¾	7½	4½	11	7½	15	14½	3½	13¾	18	7½	3½
5	11	1⅜	8	9¼	⅞	¾	8	5	12	8	16	16	3½	14	19½	8	3½
6	12½	1 7/16	12	10¾	⅞	¾	9	5½	13	9	18	17½	4	14¾	21½	9	4
7	14	1½	12	11¾	1	⅞	9½	5½	14½	9½	19	19	4½	15¾	23½	9½	4½
8	15	1⅝	12	13	1	⅞	10½	6	16	10½	21	20½	5	16	25½	10½	5
9	16½	1¾	12	14	1¼	1	11	6½	18	11	22	22½	5	20⅝	27¾	11	5
10	18½	1⅞	16	15½	1¼	1	12	7	20	12	24	25½	5½	21⅝	30¼	12	5½
12	20½	2	16	17¼	1¼	1⅛	13½	8	22	13½	27	27½	6	23	33½	13½	6
14	23½	2⅛	20	20½	1⅜	1⅛	15	9½	24	15	30	31½	6½	24⅜	37¼	15	6½
15	25	2⅛	20	21½	1⅜	1¼	15½	10	26	15½	31	33½	6½	25⅜	39½	15½	6½
16	26	2¼	20	22½	1⅜	1⅛	16½	10½	28	16½	33	34½	7½	26½	42	16½	7½
18	28½	2⅜	24	24½	1⅜	1⅛	17½	11	30	17½	35½	37½	8	27½	45½	17½	8
20	31	2½	24	27	1⅜	1⅜	19½	11½	32	19½	38½	40½	8½	28⅝	49½	19½	8½
22	33	2⅝	28	29½	1⅜	1½	20½	12	34	20½	41	43½	9½	30	53½	20½	9½
24	36	2¾	28	32	1⅜	1⅜	22½	13	36	22½	45	47½	10	31½	57½	22½	10

Condensers for the Power Plant

By William F. Fischer

General classification of condensers, including the jet, barometric, siphon ejector and surface types; description of various types; their operations, advantages and limitations.

Condensers may be divided into two general classes: jet and surface condensers. To the former class belong barometric, siphon, ejector, spirojector, induction and, in fact, all types in which the cooling water mingles with the steam. Under surface condensers are included all types in which the cooling water is separated from the steam by metallic surfaces either in the form of tubes or plates.

Jet Condensers

In this type the steam is usually admitted at the top of the condenser chamber and the water outlet is at the bottom so that the condensed steam and cooling water will drain into the wet-vacuum pump. On account of the vacuum in the condenser preventing the pressure of the atmosphere from acting upon the surface of the water, it is impossible for any suction pump to lift the water out of the condenser; hence the water must flow to the suction side of the pump by gravity. If the cooling water is to be used for boiler feed after leaving the condenser, it should discharge to a hotwell, the grease and oil being extracted before sending it to the boilers, or the exhaust steam may be passed through an oil separator before entering the condenser.

If an open feed-water heater and purifier are used the water is drawn from the hotwell by low-service pumps and discharged to the heater, from which the heated water flows to the inlet of the feed pumps by gravity. If a closed feed-water heater is used, however, the feed pumps draw their supply direct from the hotwell and force it through the closed heaters which are located on the high-pressure side of the pumps.

If the cooling water is unsuitable for boiler feed, on account of scale-forming impurities, it should be thoroughly treated before using, or it may be wasted altogether. In the latter case, however, the distilled water represented by the condensed steam is also wasted and as a consequence this may represent a considerable loss in dollars and cents each year. It might be better in such a case to use a surface condenser. If the cooling water is suitable for boiler feed, however, a jet condenser is unexcelled and should be given preference over the surface condenser because of its simplicity, low first cost, low cost of attendance, repairs, etc. Furthermore, they occupy less floor space, the erection charges are considerably lower and less cooling water is required.

Jet condensers should always be provided with a device for automatically breaking the vacuum by admitting air when the hight of water in the condenser reaches a certain point. Another method of preventing the condensing water from backing up in the engine cylinder is to provide a check valve in the exhaust pipe between the engine and the condenser.

Every condensing plant should be equipped with a free exhaust valve, so placed as to permit the exhaust steam from the engines to pass freely to the atmosphere in case the condenser fails to operate, or is shut down for repairs. The design of these valves varies somewhat with different manufacturers, but in general they are of the mushroom type, the valve being partly balanced by a lever and weights, or by weight and springs combined. These valves should be water-sealed to prevent air leakage between the seat and the disk.

Countercurrent Jet Condensers

Jet condensers of the countercurrent type are found to give much better results than the parallel-flow type and are more generally used. The injection water entering the condenser at one end and the exhaust steam at the other insure the coolest water coming in contact with the coolest steam, and the hottest steam coming in contact with the hottest water. Thus it is possible to raise the temperature of the condensing water very close to the temperature of the exhaust steam before discharging it from the condenser. This results in a considerable saving in the quantity of cooling water and also insures a much higher temperature for the boiler feed if drawn from the condenser hotwell.

In jet condensers of the parallel-flow type in which the water and steam enter at the same end and flow in the same direction, the hottest steam comes in contact with the coldest water, and the coolest steam comes in contact with the hottest water; hence the temperature of the discharge water may be some 10 to 20 degrees cooler than that of the exhaust steam entering the condenser, or the temperature corresponding to the vacuum.

Even though plenty of cold water is available for condensing purposes, it will be found advisable to work the condensing water as close to the temperature limit as possible in order to reduce the pumping charges to a minimum and keep the hotwell temperature as high as possible, at the same time reducing the work of the dry-air pump, as less air is brought in with the condensing water.

The amount of air to be handled in the case of a jet condenser is greater than with the surface condenser, due to the air carried in with the cooling water.

Barometric Condensers

Jet condensers in which the wet-vacuum pump is eliminated entirely, and the cooling water and condensed steam are discharged by gravity to the hotwell, are known as barometric condensers.

The features of this type are the same as mentioned under the general classification of jet condensers with the exception that the lower end of the condensing chamber is placed 34 feet or more above the surface of the water in the hotwell, the cooling water and condensed steam discharging into a vertical tail pipe, the lower end of which is submerged some 3 feet or more below the surface of the hotwell water, the latter forming a seal which effectively prevents air from leaking back into the condenser through the end of the pipe. Care should be taken to see that there is more water above the bottom of the tail pipe than will fill the tail pipe up to the bottom of the condenser casting; otherwise, when starting up, the water may be drawn back into the tail pipe, uncovering its end and admitting pockets of air which would tend to break the vacuum.

In condensers of the barometric type there is no danger of the condensing water backing up into the engine cylinders when the circulating pump stops, as the column of water in the tail pipe is too heavy to be forced back the full hight of 34 feet by the pressure of the atmosphere. When the circulating pump stops and the exhaust pressure builds up in the condenser, the atmospheric relief valve opens and the engine runs noncondensing until the circulating pump starts again. There is only one danger in flooding a condenser of this type when properly designed and erected, and that is if more water is pumped to the condenser than will flow freely through the tail pipe.

Another advantage of the barometric type is that it has no connection to the suction side of a wet-vacuum pump and therefore a sudden overload on the engine does not reduce the supply of condensing water at a period when there is the greatest demand for it.

The general design of barometric condensers varies considerably with different makes, and they are built on both the parallel-flow and the countercurrent principles.

Siphon or Injector Condensers

In barometric condensers of the siphon or injector type the dry-air pump may be eliminated entirely, the only pump necessary being a circulating pump, to lift the water to within about 18 or 20 feet of the condenser-inlet pipe, the vacuum taking care of the upper 18 or 20 feet of the lift. In condensers of this type the condensed steam, air and noncondensable vapors are carried out through the tail pipe with the condensing water.

If the level of the injection or cooling-water supply is not more than 18 or 20 feet below the condenser inlet, these condensers will siphon the water over as soon as a vacuum is formed, and in this case the circulating pump will not be required, the condenser operating without pumps of any kind whatsoever, making the cheapest and simplest possible arrangement. If the condenser is to siphon its water supply in this manner a cross connection should be made between the injection pipe and the tail pipe at the supply level. This connection should be provided with a gate valve for admitting water to the tail pipe when starting up; the water falling through the tail pipe into the hotwell draws the air out of the condenser cone and exhaust pipe, thus forming enough vacuum to draw the injection water up to the condenser inlet. The starting valve is then closed and the water siphons over, due to the difference in water levels and to the vacuum in the condenser. When starting the condenser it is a good plan to run the engine very slowly in order to have a small quantity of exhaust steam flowing to the condenser to assist in creating a vacuum to siphon over the water in the injection pipe. Where there is no head water available the circulating pump must be used but will have to work against only a low head.

The many different types of siphon or injector condensers, spirojector condensers, etc., all work on the same principle. The cooling water enters the condenser on the side through an annular ring surrounding a hollow cast-iron exhaust cone with the steam inlet at the top. The injection water passes downward in a thin film around the outside of the exhaust cone, and the exhaust steam flowing down inside the cone comes in contact with the falling water and is condensed.

The volume of cooling water and condensed steam falling vertically through a contracted neck in the condenser tail pipe is greatly increased in velocity at this point and the air and noncondensable vapor are drawn out of the condenser with the rapidly falling column of water, the contracted neck taking the place of an air pump.

In some types, the hollow cast-iron cone may be raised or lowered to regulate the supply of condensing water. The only danger of flooding such a condenser would be if the cone was so adjusted as to admit more water than would pass freely through the contracted neck and the tail pipe of the condenser, in which case the water would back up into the exhaust pipe.

Condensers of this type are of relatively low cost as compared with other types, and very economical when water can be obtained from a reservoir or stream at such an elevation as to make pumping unnecessary.

Ejector and Induction Condensers

In condensers of the ejector and induction types the condensing water enters at the top and passes downward through special forms of cone-shaped combining nozzles in a solid jet and at very high velocity, the momentum of the flowing water ejecting the discharge without the aid of a pump. No air pump is required with this condenser as the air and noncondensable vapors are carried away with the ejection water by the inductive power of the jet. The exhaust steam enters through the side of the condenser and passes downward through a series of inclined orifices or nozzles at high velocity. Upon coming in contact with the jet of cooling water flowing in the inner chamber, it is condensed, thus imparting the velocity of the steam direct to the cooling water.

The condenser is so arranged that it may be started by a supplementary jet of steam or water, after which it will siphon over its own water, providing the lift is not over 16 feet. Once the jet is started the cooling water is drawn in continuously by virtue of the vacuum formed and sufficient velocity is thus imparted to the jet to discharge the combined mass of condensed steam, cooling water and air against the pressure of the atmosphere. This condenser, like the others, should be provided with an automatic free-exhaust valve. To prevent water from backing up into the engine cylinder these condensers are provided with a check valve in the exhaust pipe.

Such a condenser is limited in operation as it lifts its own injection water by the velocity imparted to the jet by the exhaust steam and the vacuum formed. If the condenser is not correctly proportioned for the engine or if the load on the engine is variable, there may be times when the small amount of exhaust steam to be condensed will not be sufficient to impart the necessary velocity to the injection water and the condenser will not operate satisfactorily. Where the condenser takes its water under pressure, however, this objection does not apply, for in this case the head or pressure of the water determines the velocity of the jet independently of the volume of exhaust steam entering the condenser.

Surface Condensers

The surface condenser as usually constructed consists of a cast-iron shell into which a large number of metallic tubes of from $\frac{5}{8}$ inch to 1 inch in diameter are placed and secured at each end into a tube sheet. These are so arranged with connecting chambers that the cooling water flows through the inside of the tubes while the exhaust steam impinges upon the outside and is condensed upon striking the cooled surfaces.

In these condensers provision should always be made to insure free expansion and contraction of the tubes into the tube sheets. This is usually accomplished by passing one end of each tube through an adjustable packing gland which permits a free movement of the tube during expansion and contraction and at the same time prevents leakage between the tube and header; the other end of the tube is secured rigidly to the tube sheet. The tubes are usually made of solid-drawn brass or copper, or an alloy composed of copper, zinc and tin, and vary in thickness from No. 16 to No. 18 B. W. gage. The tube plates or headers into which the tubes are secured are usually made of the best rolled brass or muntz metal.

The outer shell or casing is made of cast iron in one or more sections bolted together. Baffle plates are usually attached to the inside of the condenser directly opposite the steam inlet to assist in distributing the steam more evenly over the tube surface. To prevent excessive flooding of the lower tubes in a surface condenser the upper tubes should be so arranged and spaced as to permit the steam to penetrate freely to the lower rows, thus insuring a more uniform cooling effect upon all the tubes.

One of the advantages of the surface condenser is that the exhaust steam, being separate from the condensing water, the condensate may be used over and over again in the boilers even though dirty or corrosive water be used for condensing purposes. There is no danger of the condensing water entering the engine cylinder, and even if the condenser becomes entirely flooded by the condensed steam, due to a failure of the wet-vacuum pump, there would be no danger of cylinder flooding as the accumulated pressure of the steam would force open the atmospheric relief valve and would allow the engines to exhaust to the atmosphere.

One objection to the surface condenser is that the grease from the engine cylinders, which is carried over by the exhaust steam, accumulates on the inside of the tubes and reduces the efficiency of the cooling surface. If the exhaust steam is first passed through an efficient grease extractor or separator this may be prevented to a large extent.

For a given capacity, surface condensers are high in first cost and are the most expensive to keep in good working condition, due to the frequent necessity for cleaning, renewing defective tubes, etc. Where boiler-feed water is a very important item, however, surface con-

densers represent a considerable saving, as nearly all the condensed steam is returned to the boilers as distilled water, free from scale-forming substances, and the saving thus effected will in most cases more than offset the additional cost of this type of condenser.

Low Pressure Fans

By John S. Leese

The use of low-pressure air fans has been rapidly increasing during the past few years. The field for their application is wide, covering as it does nearly every class of engineering work. The causes for this recent general adoption of the low-pressure air mover are not far to seek; they may be traced to recent legislative regulations regarding the ventilation and atmospheric conditions of industrial establishments; to the increased need for "hustling" in manufacturing necessitating resort to the artificial drying of goods and other time-saving propositions; to the realization by manufacturers that the absence of contaminating factors in the atmosphere of their factories and workshops militates toward the production of higher-quality goods; and to the fact that many latter-day tendencies—as, for instance, forced boiler draft—call for simple and efficient methods for the introduction of low-pressure air.

Two Types

The fans herein considered may be either of two types, the propeller type or the regular centrifugal type. The former class handles large volumes and low pressures, while the latter deals with higher resistances and speeds of discharge. The volume and discharge velocity of both types vary directly as the revolutions per minute; the pressure as the square, and the power required to drive the fan as the cube of the revolutions. In the case of the propeller type, the revolutions being constant, the volume of air discharge varies as the square root of, and the pressure inversely as, the discharge area; while the power required is least with a wide-open discharge area, increasing to about three times this amount as the area is closed. As to the centrifugal type, the volume varies directly with the area of discharge, the pressure remains practically constant throughout the whole range of area, and the power required to drive the fan increases with the volume of air handled.

Design

The following rules are important in the design of fans: (1) The blades must not be designed in such a way that eddy currents will be engendered; (2) the leading edge of the blades must offer no obstruction to the influx of the air handled; (3) the discharge edge of the blades must be designed with a similar object in view, but care must also be taken that no unnecessary velocity is imparted to the air at the discharge opening; (4) the blades must be made as narrow as possible in the direction of air travel; (5) no obstructions must be placed in the path of the air in its travel through the fan; (6) owing to the comparatively low linear velocity of the hub ends of the blades, these must be so designed that the accumulation of air pressure in the vertical plane behind the fan cannot force any air through the fan in the wrong direction in the vicinity of the hub. Adherence to these conditions will tend toward the production of a satisfactory high-efficiency fan.

Three Kinds of Efficiency

There are three kinds of efficiency to be considered in connection with fans—mechanical, volumetric and manometric. The mechanical efficiency indicates the ratio of the potential power in the air after it has been passed through the fan to the power expended in driving the fan. The volumetric efficiency refers to the ratio between the volume of air actually handled and to the theoretical volume of air which should be handled, if slip were eliminated. Manometric efficiency is the relation between the pressure actually obtained with a fan and the pressure equivalent to the highest speed of the fan. The importance of a good mechanical efficiency is obvious while volumetric efficiency is an important consideration in low-pressure, high-volume fans; that is, the propeller type of fans. Manometric efficiency is not of great importance with the propeller type, but with the centrifugal type, as the peripheral speed increases, so does the necessary strength and hence the cost of manufacture; therefore manometric efficiency is important in designing this type of fan.

Conditions of Application

The choice of a fan depends upon the application to which it is to be put. The air piping system and distributing ducts are for this reason designed, and very often installed, first. The following conditions may be applied to all air systems, for whatever purpose, since their fulfilment must be beneficial to a greater or less degree in each case. The air ducts should be as short as possible, large in cross-sectional area and internally smooth, with as few changes of direction as practicable; such changes in direction as are necessary should be effected with easy bends, with any necessary variations in the cross-sectional area made gradually and as air-tight as possible, especially so in the neighborhood of the fan.

Type of Construction

Having laid out the system, the next step is the purchase of a suitable fan. The type of construction depends upon the relation between the volume to be delivered and the pressure to be maintained. For instance, low-pressure fans of large capacity should have large airways, the speed being allowably low in comparison to that of fans designed for higher pressures and smaller volumes, the latter having comparatively small air-ways.

As a general rule, it may be said that for free air circulation the propeller type of fan is most suitable for pressures up to about ¾-in. of water, while from ⅜-in. of water upward the use of centrifugal fans may be advantageous; between these pressures the choice is not to be so definitely stated. The considerations of quietness in running and low power are in favor of the centrifugal type fan; while, from the view point of first cost and the allowable speed limit due to the construction of the fan, the propeller type of fan is preferable. By way of making a line of demarcation, it may be said that the general run of propeller fans become objectionably noisy for most services when working at above ½-in. of water.

Size

The matter of size is not so easy to decide upon. For the propeller type the choice is simple in comparison to the choice of a centrifugal fan. Usually there are several sizes obtainable which will satisfactorily perform the work required. It is necessary to consider both the first cost and the power charges for each of these sizes, which will involve different speeds and different powers. Other things being equal, the noise will be more pronounced as the size increases.

The Tennessee Geological Survey is untiring in its efforts to direct attention to the state's resources, and has recently issued a tastefully gotten up booklet entitled "The Resources of Tennessee in a Nutshell."

One company at Chattanooga will develop 85,000 hp., using the water of the Tennessee River and its tributaries. It is estimated that 75,000 hp. will be developed for farm use alone.

The following table shows the developments at the end of 1910 and the undeveloped power that is still possible in Tennessee:

	Developed Power (1910)		Undeveloped Power	
Rivers	Wheels	Hp	Minimum	Maximum
Tennessee	1691	85,548	600,000	1,000,000
Cumberland	397	8,576	25,000	50,000
Green	10	140	1,000	2,000
Mississippi	62	796	1,000	2,000
	2160	95,060	627,000	1,054,000

How Gus Stopped the Leak

By F. Webster

The influence of environment has much to do with the practice of the operating engineer. In districts where competition is keen, and where the highest grade of equipment is installed, the operation of power plants is the most exacting, and every heat unit is guarded.

But out in the open districts, as, for instance, in the coal-mining regions and in the lumber-mill country, the "catch as catch can" methods in all their phases of humor prevail. The fussy-and-particular brand of operating engineer would be entirely out of place where uncovered 4-in. steam pipes 1000 or more feet long are sometimes used, or where 3000-hp. condensing power stations are operated continuously noncondensing. The schemes and practices followed when making repairs in such power stations are many times humorous. One of the troubles in the engine room of the Little Buck mine might be taken as an illustration.

Hot water spurted spitefully at times from a sand hole in the throttle-valve casting, and unwary runners often got "stung," yet all hands around the mine soon learned to dodge hot water as effectively as they did the heels of the mules. Each new year's day brought a new crop of good resolutions for repairing the throttle, but, somehow or other, the repair went undone from year to year, possibly because other duties were as many as the calls of the signal bell from the pit, and because no two men agreed on the same method of repair. However, some things come to those who wait, and when the strike and shutdown came, Gus, the engine operator, made up his mind to fix the leak.

He cleaned out the visible part of the sand hole and built a basin of clay against the opening, binding the clay with an old overall leg around the valve. Then he went to the forge shop and heated up the big babbitt ladle with its 40 lb. or so of alloy that happened to be in it. Happy in the idea of doing a good turn, he began pouring the babbitt into the hole. The first dump spattered, but the hole remained visible. Continuing pouring, the metal disappeared in the hole, which at the end of each pause stood open as ever.

"By tam!" muttered Gus; "I fill him if it takes two pots." With the last drain of dross from the ladle, a puddle of metal held in the clay basin, and Gus rested while it cooled off. Then he removed all the evidences of his work, and filed the babbitt smooth with the valve surface. The hole seemed filled and solid and Gus viewed the job with a grunt of satisfaction.

Six weeks later steam was on and the cage with its first load started from the bottom of the shaft. Everything ran smoothly for a few seconds, when the engine suddenly took the appendicitis. That 40 lb. of babbitt had settled in its interior, and the exhaust was spitting flake babbitt onto the gravel bank back of the engine room. The slide valve shuddered and slammed, and Gus, with his hands on the levers and his eyes riveted on the indicator, stood stiff with fright. Would he be able to stop, or would the engine overwind and wreck the place by dragging the cage over the sheave? It was an anxious minute.

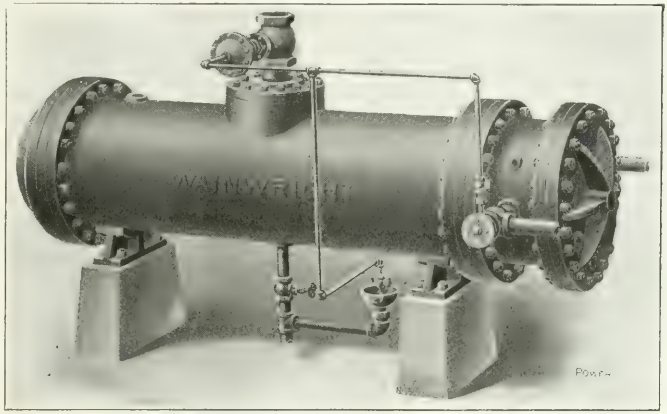
A spurt of hot water came from the sand hole, another tremulous purging of the engine, and it again settled quietly to its work. The car came to the surface and the man aboard stepped from the cage in blissful ignorance of the danger he had so narrowly escaped.

Wainwright Water Heater

The Alberger Condenser Co., 140 Cedar St., New York City, has recently developed a new type of water heater which is designed particularly to fulfill the requirements of the hot-water plant in which the service is intermittent and a constant temperature of the water is desired.

The heater is of the water-tube, instantaneous type, and is made of cast iron throughout with the exception of the heating surface, which consists of the straight, hard-brass Wainwright spiralflow tubing. The tubes are expanded into one tube head and pass through a deep stuffing-box of the condenser type in the other tube head. A spiral coil which agitates the flow of the water binds upon the inner surface of the tubes, so as to secure a very high rate of heat transmission for a given amount of heating surface. This method of accommodating expansion and contraction makes this apparatus applicable for use on either high- or low-pressure steam, for either intermittent or constant service, without any possibility of injurious strains being put upon any part of the apparatus. For installations in which the storage of water is necessary, a storage tank is furnished in connection with the heater.

When a constant temperature of the water is desired, an automatic temperature regulator of an approved manufacture is supplied. The accompanying illustration shows the heater as equipped with the regulator.



Wainwright Domestic Water Heater

List of Water Equivalents

The United States Geological Survey is authority for the water-measurement equivalents given in the following list:

One second-foot equals 40 California miner's inches (law of Mar. 23, 1901).

One second-foot equals 38.4 Colorado miner's inches.

One second-foot equals 40 Arizona miner's inches.

One second-foot equals 7.48 United States gallons per second; equals 448.8 gal. per minute; equals 646,272 gal. for one day.

One second-foot equals about one acre-inch per hour.

One second-foot for one 31-day month equals 61.49 acre-feet.

One million United States gallons equals 3.07 acre-feet.

One California miner's inch equals 0.187 United States gallon per second.

One Colorado miner's inch equals 0.195 United States gallon per second.

One acre-foot equals 325,850 gal.

One cubic foot equals 7.48 gal.

One horsepower equals one second-foot falling 8.8 ft.

The formula

$$\frac{\text{Sec. ft.} \times \text{fall in ft.}}{11} = \text{net hp.}$$

may be used to calculate water power on a waterwheel realizing 80 per cent. of the theoretical power.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Increasing the Capacity of Large Gas Engines

By F. E. Junge

The problem of increasing the capacity of large gas engines by scavenging with compressed air has recently been attacked with much success by Wilhelm Hellmann, in Hörde, Germany. His investigations were contributed to the transactions of the Society of German Engineers, and the following is a summary of the results:

Theoretical Difference of Output of Ordinary and Scavenged Engines

The following basic values are assumed in the calculated comparison:

Compression space volume, 18 per cent. of piston displacement.

Weight of one cubic meter air and gas.

Coefficient of expansion = 0.00367.

Absolute pressure of gases remaining in cylinder = 1.05 atmospheres.

Absolute pressure of gas-air mixture taken in = 0.90 atmosphere.

Temperature of remanent gases = 500 deg. C.

Temperature of gas and air mixture taken in = 20 deg. C.

The influence of the cylinder walls is neglected in the calculations because the results are thereby not materially affected. With a compression space of 18 per cent. of the piston displacement, the temperature of the mixture of burnt gases remaining in the cylinder and of the new charge of gas and air taken in is 55.5 deg. C. In contact with the fresh mixture, the residual gases in the compression space contract to a volume of 7.67 per cent. of the total, thereby increasing the volume of the new charge of gas and air 18 — 7.67 = 10.33 per cent. Hence the total volume of active charge becomes 100 + 10.33 = 110.33 per cent. of the piston displacement. The engine on which the above calculation is based is a new blast-furnace gas engine built in Germany, in which the relatively small compression space of 13 and 15 per cent. formerly employed has been abandoned in favor of 18 per cent. in order to avoid the high explosion pressures which caused sudden high strains on rods and bearings and reduced the life of the engine.

The influence of the compression space on the temperature of the charge and on its volume, and the effect of scavenging, are shown in the table. The temperature of the mixture increases with the increase of the compression space without scavenging, and the weight of gas and air taken in, and therefore the output, decreases. Moreover, the mixture is considerably impaired by the increasing volume of residual burnt gases and the output of the engine is thereby still further reduced.

In the scavenged engines, for which the absolute pressure of the scavenging air is put at 1.25 atmospheres, after thorough scavenging of the residual gases the gas-air mixture in the cylinder at the end of the suction stroke is equal to the full volume of piston displacement plus clearance space, and at a temperature of 20 deg. C. Compared with the heated mixture of an engine working without scavenging, the volume of active charge in the scavenged engine is 140.2 per cent., which gives an increase in output of 27.3 per cent., using a compression space of 25 per cent. This gain in output is due to the increased volume of the mixture; also to the fact that in a scavenged engine, in spite of lower compression pressures, the same explosion pressure is obtained as with ordinary engines having a compression space of 18 per cent. of the piston displacement.

In contrast to the figures for the ordinary engines, those for the scavenged engines show a constant charge temperature and an increase, with increasing compression space, of the volume of fresh mixture drawn in during the suction stroke. The increase in output over the normal engine is notable. The compression spaces of 30 and 50 per cent. given in the table are of no use in practice because they give a low thermal efficiency owing to the low compression, but a compression space of 25 per cent. gives favorable results.

The calculated gain of output of 27.3 per cent. is due partly to the increased volume and partly to the reduced temperature of the charge, whereby the total weight of active charge is much increased, it being assumed that the available volumes of the scavenged and unscavenged engine, as compared, contained pure mixtures of the same composition. This, of course, is not the case, for the 110 per cent. of the mixture in the ordinary engine is diluted during the suction and compression strokes by the residual burnt gases, which constitute 7.6 per cent. of the stroke volume. Hence the incoming mixture must always have a surplus of air in order to attain good combustion.

Compared with a perfect mixture, the actual mixture in the engine contains less gas and more air than are required. If the 110 per cent. of mixture were not impaired by the residual gases, a more correct ratio of gas and air could be used, and with the same contraction in the volume of burnt gases an increased capacity of 7.67 per cent. would be attained. If these considerations are referred to the scavenged engine, an increased capacity of

$$\frac{7.67 \cdot 140.2}{110.33} = 9.8 \text{ per cent.}$$

would be realized. The theoretical limit of increased output would therefore be 27.3 + 9.8 = 37.1 per cent.

COMPARISON OF SCAVENGED AND ORDINARY FOUR-STROKE ENGINES

Pressures are absolute, in atmospheres. Temperatures are in Centigrade degrees.

	Nonscavenging			Scavenging		
Clearance volume in per cent. of stroke volume	25	30	50	25	30	50
Compression ratio	5	4.3	3	5	4.3	3
Compression pressure, atmospheres	7.9	6.5	4	7.9	6.5	4
Temperature of residual gases	550	575	650	.....	.....	.....
Aspiration temperature of mixture	20	20	20	20	20	20
Pressure of aspirated mixture	0.9	0.9	0.9	0.9	0.9	0.9
Temperature of total cylinder contents before compression	69.8	79.9	118.5	20	20	20
Volume of concentrated residual gases, per cent. of piston displacement	10.4	12.5	21.2	.....	.....	.....
Charge volume of gas-air mixture, per cent. of piston displacement	114.6	117.5	128.8	125	130	150
Charge volume of gas-air mixture referred to an engine with a compression space of 18 per cent. and a charge temperature of 55.5 deg.	109.7	109.5	108.2	140.2	145.9	168.3
Charge volume of gas-air mixture referred to an unscavenged engine of equal size, per cent	.....	.....	.....	146.1	156.8	200

Prof. Köhler, of Aachen, maintains that the gain through scavenging is even greater. He says an ordinary engine with a clearance of 18 per cent. has a charge volume of 87.3 per cent., while the scavenged engine with 25 per cent. clearance has a charge volume of $0.9 \times 125 = 112.5$ per cent. Assuming that the effective capacity is proportional to the charge volume, the gain of output would be 28.6 per cent. and the total theoretical gain $28.6 + 9.8 = 38.4$ per cent.

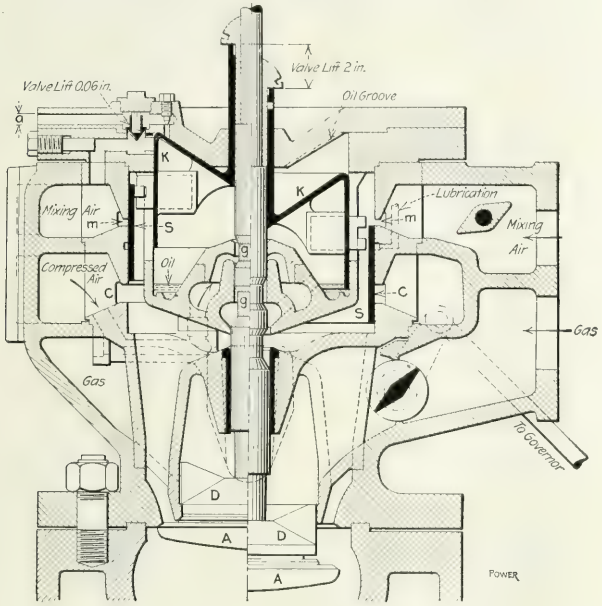


FIG. 1. COMBINED INLET AND SCAVENGING VALVES

DETAILS OF CONSTRUCTION

Compressed scavenging air is conducted to the engine through a special pipe and its entrance into the space behind the inlet valve is governed by a separate slide valve, termed the scavenging valve. This valve can be operated in various ways; one way is by connecting it with an air piston, as shown in Fig. 1, where *K* is the piston. In the left-hand section of the drawing the air piston and scavenging valve are shown in the highest position; in the right-hand section, in the lowest position. On its way down the combined air piston and scavenging valve is mechanically actuated by the valve-gear which opens the main inlet valve. A slight resistance to the downward travel of the slide valve is offered by the vacuum above the piston *K*, which can be adjusted by means of the small air-admission valve *a*.

About 1 per cent. after reaching the dead point the ports for the admission of scavenging air are closed, while the ports for the admission of mixing air remain covered for a while in order to permit, for a fraction of the suction stroke, the entrance of pure gas into the cylinder, where it meets the scavenging air in the compression space. The length of this period of pure gas admission is very important and depends entirely upon the heat value of the gas. It may be extended as far as 30 per cent. after the valve has reached the dead point. At the close of this period air and gas are admitted together in proper proportions for the rest of the suction stroke.

The various phases of the process are shown in the valve-elevation diagram, Fig. 2. The air piston *K* and scavenging valve *S* being balanced, there is no increase in the load on the valve-actuating gear. The greatest strain is exercised through the closing spring at the highest elevation of the valve. On its way up the combined air piston and scavenging valve first closes the ports *m* for the admission of mixing air and then opens the ports *C* for the admission of scavenging air, which fills the space behind the main inlet valve *A*, so that the expulsion of the burnt gases can begin any time during the exhaust stroke. The upward movement of the main inlet valve *A* and that of the combined air piston and scavenging valve are, of course, accomplished separately.

The seating of the main valve is done by the closing spring, but the lifting of the combined air piston and scavenging valve is done by the compressed scavenging air which enters through a small port formed by grooves *g* around the valve spindle and flows beneath the air piston *K*. A period of 2½ piston strokes is available for lifting the combined air piston and scavenging valve into its highest position. To prevent sticking at the start, the scavenging valve should be lubricated freely and should be actuated from time to time when the engine is standing idle.

In order to keep the compressed air from entering into the gas main in case the gas valve should not work, and to prevent premature ignition and backfiring in the valve chamber, a special gas valve *D* is provided concentric to the main air-inlet valve. The mixing of air and gas, therefore, does not take place until the two media pass the inlet valve on their way into the cylinder, and the admission of the two is closed off at the same time. If for some reason or other it is desired to run the engine without scavenging, the delivery of compressed scavenging air is stopped and the combined air piston and scavenging valve remains in its lowest position, where the ports for the admission of mixing air are open, as will be seen from Fig. 1.

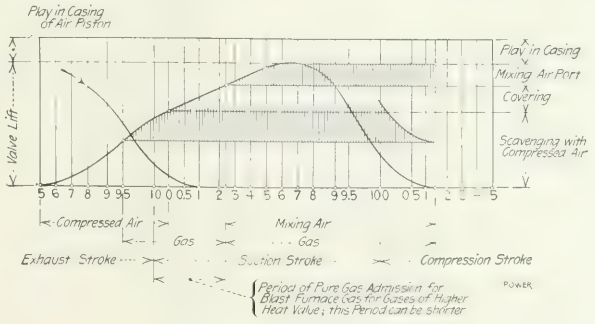

Play in Casing of Air Piston
Valve Lift
Play in Casing
Mixing Air Port
Covering
Scavenging with Compressed Air
5 6 7 8 9 9.5 10 0 0.5 1 2 3 4 5 6 7 8 9 9.5 10 0 0.5 1 2 3 5
Compressed Air
Mixing Air
Gas
Gas
Exhaust Stroke
Suction Stroke
Compression Stroke
Period of Pure Gas Admission for Blast Furnace Gas for Gases of Higher Heat Value; this Period can be Shorter
POWER

FIG. 2. VALVE-LIFT DIAGRAM

SCAVENGING PUMPS

Unless air under pressure is available from a blower, as is the case in blast-furnace and steel-smelting plants, a special scavenging pump is required, which

is preferably coupled directly to the crankshaft of the gas engine. Fig. 3 shows a double-acting air pump with slide valves, which are best fit for the purpose. The slide valve is superior to the automatic valve not only because it possesses greater operating reliability but because the losses through negative work are lower, provided a pressure of not more than 0.3 of an atmosphere is to be dealt with. The vertical arrangement of cylinder and valve affords easiest lubrication, low losses through friction and inconsiderable wear. Pressure variations of the scavenging air have no influence on the succeeding charging process, because scavenging and charging are independent of each other. High-pressure air for scavenging gives even better results than low pressure, because the expulsion of burnt gases is more thorough.

The pump shown in Fig. 3 serves as an auxiliary for a double-acting tandem gas engine with cylinders 20 in. in diameter and a stroke of 28 in., running at 150 r.p.m. The pump-cylinder diameter is 21 in. and the stroke is 12 in. Under normal conditions, this gas engine has an output of 543 hp. The air required for scavenging must have a volume 1.75 times the compression space, and the latter is 25 per cent. of the stroke volume. Hence the quantity of air needed is 597 cu.ft. per minute and the air pump has to operate at 150 r.p.m. in order to deliver the required amount. The average air-pump diagram shows a compression pressure of 1.25 atmospheres, absolute, and a mean indicated pressure of 0.3 of an atmosphere. The scavenging pump absorbs 11.847 hp., or 2.17 per cent. of the normal indicated power of the gas engine.

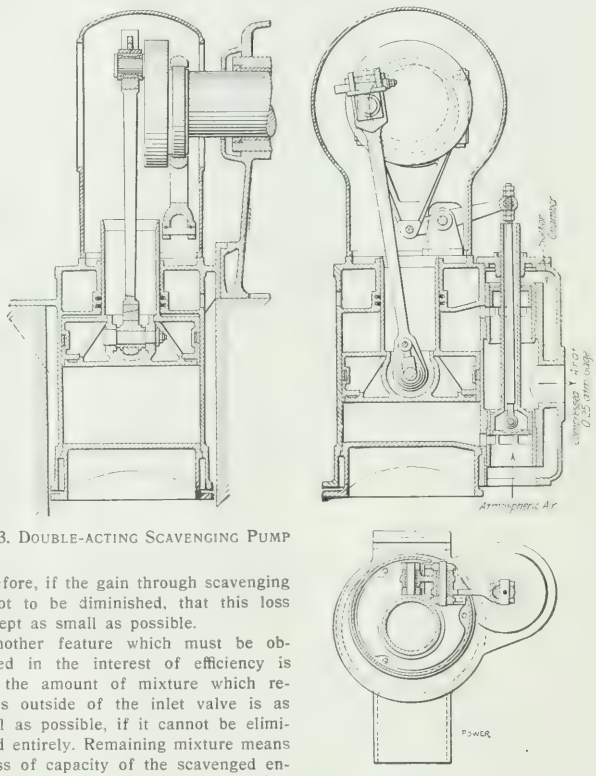


FIG. 3. DOUBLE-ACTING SCAVENGING PUMP

CONDITIONS FOR INCREASING CAPACITY

The scavenging of the compression space, the expulsion of burnt gases, and their replacement by cold air are alone not sufficient to realize a definite increase of output. The scavenging is only a preparatory process and must be supplemented by immediate charging, it being essential that to the air in the compression space is added a corresponding quantity of gas without additional losses. In order to attain this the pressure of the scavenging air must be in the neighborhood of 1.25 atmospheres, absolute, and the cross-sections of the passages in the inlet casing must be of ample proportions to avoid throttling. There is no throttling in the pipes, because the scavenging and the mixing air are conducted separately. Hence, the scavenging air can expel the burnt gases with undiminished force, beginning during the middle of the exhaust stroke when the valve opening has reached its maximum.

It is essential to make the space between the inlet valve and the scavenging valve as small as possible, so that the air in the inlet-valve chamber assumes the suction pressure immediately after the beginning of the suction stroke, thereby assisting the influx of gas into the cylinder. Hellmann admits that in an ordinary unscavenged engine with a compression space of 18 per cent., the loss due to ineffective expansion is 1.9 per cent., while in a scavenged engine with a compression space of 25 per cent. plus 5 per cent. in the inlet chamber, the loss is 3.2 per cent., assuming expansion in both cases from 1.05 to 0.95 atmospheres absolute. It is essential, therefore, if the gain through scavenging is not to be diminished, that this loss be kept as small as possible.

Another feature which must be observed in the interest of efficiency is that the amount of mixture which remains outside of the inlet valve is as small as possible, if it cannot be eliminated entirely. Remaining mixture means a loss of capacity of the scavenged engine proportionate to the amount of mixture; instead of this mixture, which is scavenged into the exhaust pipe, a corresponding volume of air is taken into the cylinder at the beginning of the suction stroke. Hence, when the scavenging process is over no additional air should be admitted, but gas should be introduced in sufficient quantities to make a perfect mixture. The combination valve shown in Fig. 1 is so constructed that no mixture remains outside of the inlet after the latter is closed, because the mixing of the two media is performed while they pass into the cylinder.

A further essential condition for successful scavenging is that the period of gas influx be as long and the cross-section of gas passage as large as possible. This is especially important when driving dynamos, but for slow-speed gas blowers the period of gas intake may be shorter. Gas admission should begin 5 per cent. before the piston starts on its suction stroke and should not end until 10 or 15 per cent. after the suction stroke is completed. The aspirating action of the compressed air flowing in, together with the construction of the inlet, which acts like an injector, causes the acceleration of the gas to begin as early as 5 per cent. before the dead center. This effect may be augmented by a suitable layout of the exhaust piping, though the latter depends largely on local conditions.

When operating on blast-furnace gas it is advisable to continue the period of pure gas admission during 25 per cent. of the suction stroke; then gas and air enter into the cylinder in the usual manner. If these precautions are taken the cylinder at the beginning of the compression stroke contains an undiluted charge, which gives perfect combustion, as shown by the indicator cards. But it must be emphasized again that a notable increase of output by scavenging can be realized only when the losses of the process are reduced as far as possible.

Lack of regard for detail construction is responsible for the fact that the earlier types of scavenging engines have not met with complete success. They had no separate organs for controlling the admission of scavenging air. The nace gas of the usual heat value, mean effective pressures of 693 normal and 790 maximum are obtained. The corresponding mechanical efficiency is 82 per cent. and 84.5 per cent. respectively. While theoretically there is a difference

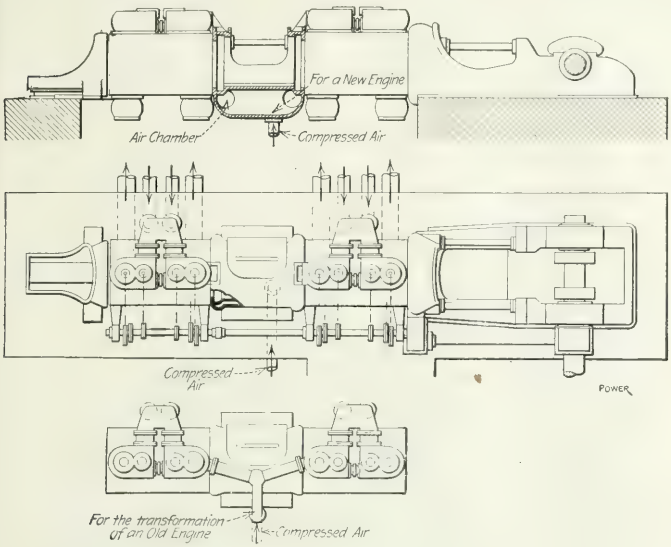


FIG. 4. AIR PIPING FOR A SCAVENGING FOUR-STROKE TANDEM ENGINE

inlet valve of the gas engine was the pressure valve of the pump. The space between this valve and the piston of the air pump was very large and this space was still further increased by the addition of the compression space.

At the beginning of the suction stroke these large spaces were filled with compressed air which expanded during a considerable portion of the suction stroke and prevented the aspiration of gas in due time. Moreover, at the end of the suction stroke of the pump the air in these spaces was at a pressure below the atmospheric, which was transmitted to the charge in the working cylinder; hence, this cylinder was not filled up to its full capacity and the gain through scavenging was accordingly reduced. Hellmann estimates the loss through expansion in the old scavenging engine at 8.7 per cent., and the loss due to mixture remaining in front of the inlet valve at 8 per cent., making a total loss of 16.7 per cent. On this basis the superiority of the new over the old scavenging engine would be 16.7 — 3.2 = 13.5 per cent.

THERMAL CONSIDERATIONS

The indicator diagrams in Fig. 5 are obtained with a clearance volume of 25 per cent. and show a mean effective pressure of 7.2 and 7.3 atmospheres, with compression pressures of 7.5 and explosion pressures of 19 and 19.5 atmospheres, respectively. With blast-furnace gas of the usual heat value, mean effective pressures of 693 normal and 790 maximum are obtained. The corresponding mechanical efficiency is 82 per cent. and 84.5 per cent. respectively. While theoretically there is a difference of 5 per cent. in the thermal efficiency in favor of the smaller compression space (18 per cent.), this theoretical reduction is more than neutralized by the superior ignition and combustion of the chemically favorable and pure mixture in the larger compression space (25 per cent.), a fact which is established by the higher thermal efficiency of large two-stroke-cycle engines. As will be seen from the indicator cards, the explosion pressures do not rise above the normal (about 20 atmospheres) which has been found good practice for large work, while the output is considerably increased.

The operating reliability of scavenged engines is by no means less than that of ordinary engines. On the contrary, owing to the cooler charge, the temperature of the cycle is reduced during the whole of the suction stroke. Again, the temperature is reduced during the whole of the compression stroke, owing to the lower compression pressures used. Moreover, about 50 per cent. after the beginning of the exhaust stroke, scavenging sets in, whereby the mean temperature of the exhaust period is also reduced. In addition there is the favorable expansion due to perfect combustion, which gives an expansion curve approaching the adiabatic.

There is only one phase of the process when temperatures rise above the ordinary, namely, during explosion. For the rest of the time the cyclic temperatures are lower. Therefore the life of the engine, and especially the durability of the flanged exhaust socket, which always shows an inclination to crack as a result of overheating, is increased.

With equal heat value per unit of charge volume, the heat of the charge in large gas engines increases as the cube of the cylinder diameter, while the heat-conducting wall surfaces increase only in the square, compared to a smaller engine. Also the thickness of the walls increases and so does the temperature, in spite of water cooling. Perfect scavenging is apt to equalize the increasing internal temperature of large gas engines, to prevent burnt particles of the lubricant from causing preignition and thereby to increase the operating reliability of the plant.

EXHAUST PIPING

It is known that the design of the exhaust piping has a great deal to do with the efficiency of gas-power plants, because all obstacles causing eddy currents and back pressure reduce the output. The stop diagram in Fig. 6 shows the effect of poor exhaust-pipe arrangement and that in Fig. 7, which was obtained under the same general conditions, shows the improvements realized by facilitating the conduction of the waste gases into the atmosphere. The first two diagrams, of which the one is obtained without and the other with the injection of water into the exhaust, show the resistance which the outrushing gases encounter during 15 or 20 per cent. of the exhaust stroke. They also show that at some 20 per cent. before the end of that stroke the vac-

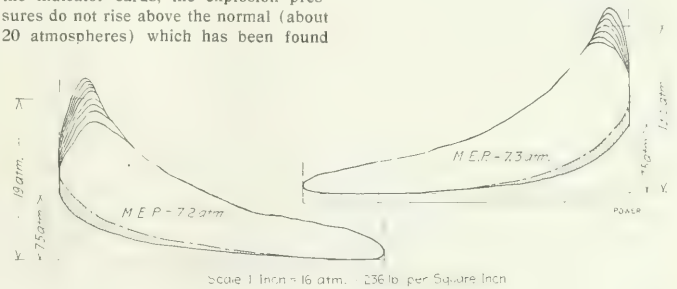


FIG. 5. DIAGRAMS FROM SCAVENGING ENGINE WITH COMPRESSION RATIO OF 5

ium is turned into a back pressure of 0.1 to 0.16 of an atmosphere, which prevails during the period of scavenging and makes the latter process even temporarily inefficient.

Another result of the back pressure in the latter part of the exhaust stroke is that the suction line does not begin until 6 to 9 per cent. beyond the dead center, whereby a complete filling of the cylinder

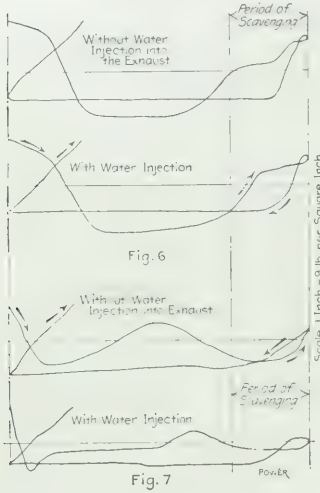

Period of Scavenging
Without Water Injection into the Exhaust
With Water Injection
Scale 1 Inch = 9 lb. per Square Inch
Without Water Injection into Exhaust
Period of Scavenging
With Water Injection
POWER

Fig. 6

Fig. 7

STOP DIAGRAMS, SHOWING EFFECTS OF DIFERENT EXHAUST PIPING

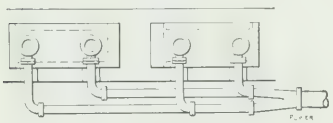


FIG. 8. A GOOD ARRANGEMENT OF EXHAUST PIPING

with active charge is made impossible. With the improved layout of the exhaust piping there is much less resistance in the early part of the exhaust stroke and atmospheric pressure prevails during the scavenging period, whereby scavenging and charging are made more effective.

Experiments have shown that it is advantageous to lay out the exhaust piping for both sides of the cylinder in the same manner, and that curves or elbows which may cause eddying must be avoided as much as possible in order to secure an even flow. Fig. 8 shows how to lay out the exhaust piping for large gas engines. With this arrangement the exhaust of one combustion chamber has no clogging influence on the scavenging which goes on in another combustion chamber at the same time.

Summing up, the Hellmann system affords a notable increase of capacity at low additional cost. The mean temperatures and pressures are not higher than they are ordinarily, while the engine output is increased 25 per cent. and more. Preignition is avoided and heat consumption improved. By choosing a smaller type of engine the bulk of plant is reduced and the ratio of plant output and initial cost becomes more favorable. By shutting off the scavenging air the engine continues to run in the ordinary manner. Any existing type of large gas engine may be thus improved.

LETTER

Effect of Temperature on Crude Oil

BY C. E. HOWELL

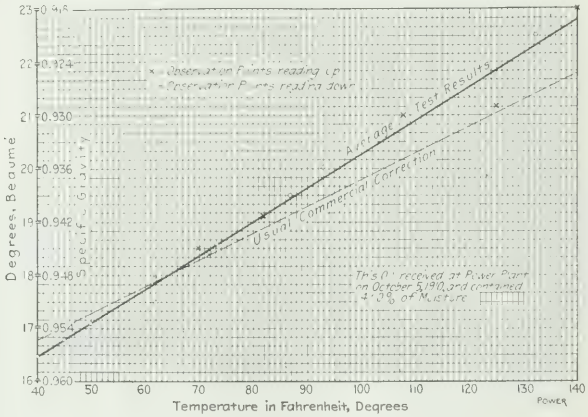
In the Nov. 14, 1911, issue of POWER there was a short article by a Mr. Lyons on the effect of temperature on the specific gravity of crude fuel oil, accompanied by a curve of the results of tests made to determine this effect. The article attracted the attention of the writer because he had made a similar test about a year previously.

Upon unearthing the curve made by himself and plotting the results on the chart in POWER, it was found that the points of both the rising temperature and the falling temperature tests coincided exactly with those in the POWER chart. Furthermore, the percentage of moisture in the oil used was the same, ⅞ per cent. The writer of the article in the Nov. 14 issue gave Oakland, Calif., as his address, but the test by the present writer was made in Los Angeles. Investigation fails to indicate that any copies of the result of the Los Angeles test have ever been distributed. The writer takes it that it is merely a very unusual sort of coincidence. However, it may not be amiss to explain the present chart.

Primarily, the data were taken to check the well known purchasing method of deducting or adding one degree Baumé for every 20 deg. F. above or below 60 deg. F., respectively, to reduce the specific gravity of the oil purchased to what it would be at 60 deg. F. The chart indicates that 1¼ deg. Baumé should be deducted or added, as the case may be, for each 20 deg. F. difference in temperature. The chart has since been used in obtaining the approximate gravity of fuel oils at different temperatures while heating them for firing purposes. By also giving the specific gravity with water as the basis of comparison, the correction for expansion may be found.

The commercial correction for the effect of temperature on the bulk of crude oil is 1 per cent. for each 20 Fahrenheit degrees of difference in temperature. Referring to the correct curve, however, one finds that the specific gravity of this oil at 60 deg. F. is 0.9495, while at 80 deg. it is 0.9420. The percentage of expansion in raising the temperature from 60 deg. to 80 deg. F. is

$$\frac{100 \times 0.9495}{0.942} - 100 = 0.8 \text{ or, } 1 \text{ per cent.}$$



EFFECT OF TEMPERATURE ON CRUDE OIL

and the oil companies therefore get the worst of it on the expansion correction for change in temperature when using the old allowance of 1 per cent.

A Thirty Day Run

A British firm is building two sets of eight-cylinder, four-cycle Diesel oil engines of 2500 combined horsepower for the "Jutlandia," which was recently launched. One of these engines was rigged up on the "bench" and attached to a dynamo. It was then given a 30-day continuous night and day nonstop run, 28 days of which were at full power, one at three-quarters and one at half power, burning Scotch shale fuel oil of a specific gravity of 0.85. During the 30 days' run the engine was never stopped or adjusted in any way, no trouble whatever was had, and it ran as steadily on the last day as on the first.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Westinghouse Belt Driven Alternators

The accompanying engravings illustrate the construction of the latest form of Westinghouse belt-driven alternating-current generator designed particularly for operation in industrial plants and small central stations. Having in mind the usual conditions of operation in such plants, special efforts were made to obtain as simple and rugged construction as possible.

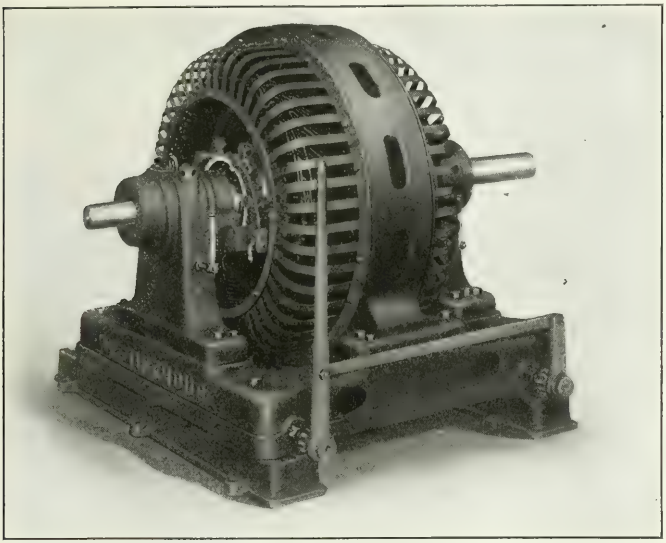


FIG. 1. WESTINGHOUSE BELT-DRIVEN ALTERNATOR

The field magnet is the revolving member and it consists of a laminated steel spider (Fig. 2) carrying laminated magnet poles which are held on the spider by dovetails. The dovetail slots are stamped in the disks of the spider and the corresponding dovetail is stamped in the steel sheets forming the magnet pole. The dovetail on the pole is smaller than the slot in the spider and is secured in the slot by means of two taper keys extending the whole length of the slot. Fig. 3 shows the construction of a magnet pole. The rectangular slots near the edge of the pole face are provided to take the bars of a squirrel-cage winding, arranged as shown in Fig. 4.

The function of the squirrel cage around the magnet pole faces is to "damp out" any tendency to "hunt" when operating in parallel with other machines. The squirrel cage also partly neutralizes the armature reaction of single-phase machines and thereby improves the regulation. The construction of the cage is so clearly shown in the picture that a detailed description is unnecessary. It is supplied only on machines of 75 kilovolt-amperes and larger.

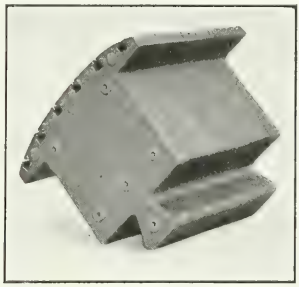


FIG. 3. FIELD-MAGNET POLE

Fig. 5 shows a field-magnet spider with the poles and coils in place. The coils are of the usual form-wound type, completely insulated before being put on the cores. It will be evident on close inspection that two retaining straps are

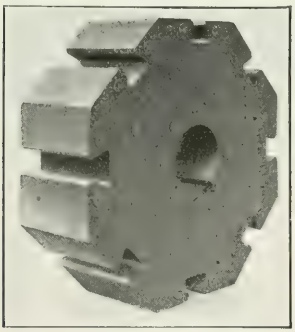


FIG. 2. FIELD-MAGNET SPIDER

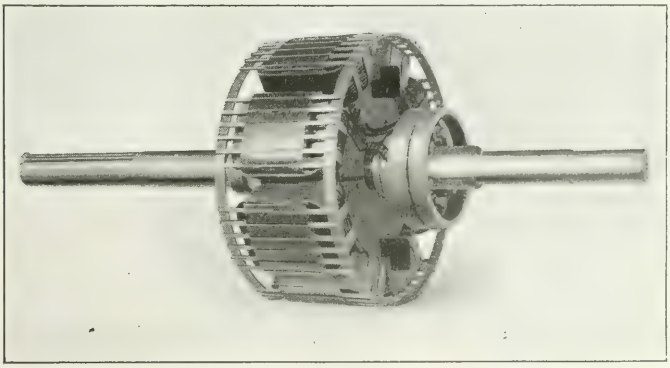


FIG. 4. COMPLETE FIELD MAGNET, WITH SHAFT AND SLIP RINGS

applied to the end of each magnet coil in such a way as to restrain the projecting portions from spreading radially under the influence of centrifugal force. The polar extensions protect those parts of the coil lying parallel with the shaft.

The armature core is of the usual laminated type, provided with entirely open slots and mounted in a substantial cast-iron housing, as shown in Fig. 6. The armature coils are form-wound and individually insulated; they are held in the core slots by fiber wedges driven in small slots in the flanks of the core teeth.

In sizes above 75 kilovolt-amperes the shaft is supported by pedestals, as illustrated in Fig. 1; in smaller sizes, circular journal brackets are bolted to the stator housing as in the case of small direct-current machines. These generators are built by the Westinghouse Electric & Manufacturing Co. in sizes ranging from 30 to 200 kilovolt-amperes, for 60 cycles frequency and for all standard alternating-current voltages from 240 up to 2400.

LETTERS

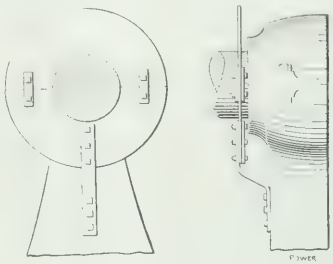
Keeping Oil off the Commutator

I once had charge of an electric generator which was directly driven by its engine, the armature being mounted on a crankshaft extension, between the engine flywheel and the outboard bearing. Continuous trouble was experienced by oil being thrown out of the bearing onto the brush gear and commutator, due to the shaft whipping slightly in the out-end bearing block. Drops of oil would be thrown from the top of the brass and no matter how finely the box was adjusted no cure for the trouble was effected. The maker's representative saw the job and admitted that it must be some balancing fault in the crankshaft (running at 250 r.p.m.) which caused the oil to be jerked out so.

He left without suggesting a remedy and as a last resort I fixed up the guard or shield shown in the accompanying drawing. The shield was made out of $\frac{1}{16}$-in. sheet brass held by braces $\frac{1}{8}$x1 in. and $\frac{1}{8}$x1$\frac{1}{2}$ in., of mild steel. The hole in the brass disk was made $\frac{1}{8}$ in. larger in diameter than the shaft, which allowed $\frac{1}{16}$-in. clearance all around, and the disk was split horizontally. The drawing shows the method of mounting clearly enough, I think. It will be evident that the top half of the disk may be removed, if it should be desired to lift the shaft out, by the removal of two bolts above the horizontal seam. All the oil thrown out of the bearing is caught on the brass plate and no further trouble has been experienced from this cause.

J. E. Black.

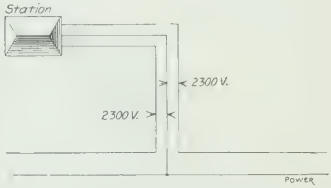
Manchester, Eng.



Mr. Black's Oil Guard

An Improvised Three-Phase System

I was called on a short time ago to install a 2300-volt three-phase generator and switchboard to take the place of an 1100-volt single-phase machine that had burned out. The owners did not have the time, nor the desire, to go to the expense of wiring the town for three-phase distribution and the new machine was not large enough to carry the load running single-phase.



Improvised Three-phase System

I opened one side of the old main line near the center of distribution and connected it to the station as shown in the diagram. The load is as nicely balanced as any that I have seen. As most of the transformers were of modern types with 1100- or 2200-volt primary windings they did not give much trouble. All 1100-volt transformers that were worth saving were connected in series and used.

D. W. Scarborough.

Richmond, Tex.

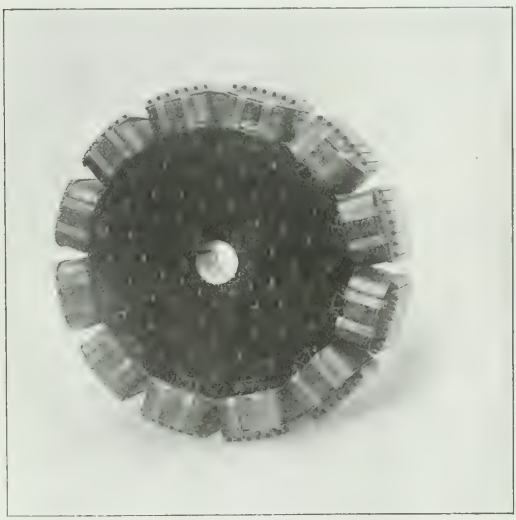


Fig. 5. Field Magnet, with Coils

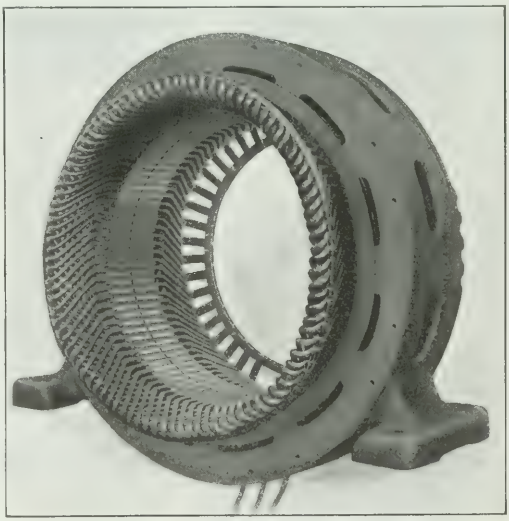


Fig. 6. Armature Complete in Housing

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Heating and Ventilating System of the Ritz-Carlton Hotel

By Charles A. Fuller

The heating and ventilating system designed for the addition to the Ritz-Carlton Hotel, at Madison Ave. and Forty-sixth St., New York City, has several features which may perhaps be of interest to engineers in this line of work. Because of the unusual arrangement of the building, it was necessary to divide the ventilating into four separate systems as follows: ball room and banquet hall, private dining room, service floors and toilet-room exhausts.

The system for the ball room and banquet hall is the largest of the four, handling about 50,000 cu.ft. of air per minute. These rooms are each 50 ft. wide and 90 ft. long. The banquet room is located below the street level and has a ceiling height of 20 ft. The ball room is located directly above the banquet hall and has a ceiling height of 30 ft. Above the ball room is located the blower room, containing all the ventilating apparatus for this system.

The air in entering first passes through a tempering coil, then through an air washer to the intake of the supply fan. From the supply fan, it passes through a reversing damper and the reheater to the distributing ducts. The tempering coil consists of two banks of American Radiator vento seetions 40 in. high. Each bank is divided into four groups, two groups high and two groups wide, placed back to back. Each group contains 16 sections, making a total of 1376 sq.ft. of radiating surface.

The steam supply to the first bank is controlled by a thermostat placed in the cold-air inlet, and the steam supply to the second bank by a thermostat placed between the second bank and the air washer. The first thermostat is adjusted to close the steam supply to the first bank when the temperature of the entering air is above 25 deg.; the second is adjusted to close the steam supply to the second bank when the air passing through the tempering coil is above 50 deg. This arrangement keeps the temperature of the air entering the air washer at 50 deg., regardless of variations in the outside temperature, so long as it is below 50 deg. This is necessary in order to maintain a constant humidity in the rooms, which is a very desirable feature.

The reheater consists of three banks of American Radiator vento sections 60 in. high. Each bank is divided into two groups placed back to back, and each group contains 16 sections, making a total of 1536 sq.ft. of radiating surface. The main steam supply to the reheater is equipped with a diaphragm valve controlled by a thermostat placed in the hot-air duct leading from the heater.

A bypass is provided below the reheater. The hot air from the reheater and the tempered air from the bypass then pass through thermostatically controlled mixing dampers which operate so as to produce the required temperature in the room supplied. With this system, each room must have a separate duct and a set of mixing dampers, which insures that the required amount of air is being constantly delivered to each room regardless of outside temperature changes.

After determining the heat losses from the various rooms, it was found that the required temperature of the air from the reheater for extreme conditions was approximately 100 deg. This temperature could be obtained with the tempering coil as described and a reheater composed of two banks and maintaining a velocity through the heater of 1200 ft. per minute, requiring a free area of about 42 sq.ft. As the available head room was only 7 ft., the necessary width made this arrangement practically prohibitive.

It was then decided to put in three banks of heaters, which would make the resulting temperature 120 deg. with a velocity of 1200 ft. per minute. Then by passing only 75 per cent. of the air through the heater and 25 per cent. through the bypass in the extreme conditions, the resulting temperature directly beyond the mixing dampers would be 100 deg., and by so doing the width of the reheater was cut down about 25 per cent. This arrangement, however, does not reduce the amount of heating surface necessary.

Means for cooling the air in summer time, in addition to the cooling effect of the air washer, is also provided by direct-expansion cooling coils placed in the spray chamber of the air washer. A constant spray of water is kept flowing over the coils, which prevents the formation of frost on the outside of the pipes. The humidity is controlled by cooling the air to a definite point below the outside temperature, which also lowers the temperature below the dew point and some of the moisture is condensed. This condensed moisture is removed when passing through the eliminator. The temperature of the air in passing through the distributing ducts and into the rooms is raised due to the warmer outside temperature and, consequently, the humidity is lowered to the desired point.

Each of the rooms supplied by this system has a series of registers at the floor level and also at the ceiling level. During the winter time, when warm air is supplied, this air enters through the registers located at the ceiling and the floor registers serve as the exhaust registers. In summer, however, when cold air is supplied, the floor registers serve as the supply and the exhaust is taken out through the ceiling.

With this arrangement, the best possible ventilation is secured. In winter time, the air enters the room at a higher temperature than the room and is cooled after entering. This causes a natural flow of air downward, and for this reason, the proper point to remove the foul air is at the floor level.

In summer, the air enters the room at a lower temperature and is heated after entering. This produces an upward flow of air and for the same reason the proper point to remove the foul air is at the ceiling; this is particularly true of rooms with very high ceilings where air cooling is desired. If the cold air were introduced at the ceiling, all the refrigerating effect would be lost by the time the air had reached the breathing line.

This reversing of the direction of flow is produced by means of a reversing damper shown in Fig. 1. In the position shown on the drawing, the damper is set for cold-weather conditions or for delivering warm air to the rooms through the ceiling registers. The floor registers are connected to a system of vertical flues which combine into one main duct passing up through the floor to the blower room at the point *A* and thence through the opposite compartment of the reversing damper to the exhaust fan.

To deliver cold air from the air washer to the rooms through the floor registers, the damper is set at right angles to the position shown. The fresh air then passes

through the washer and supply fan and then the reversing damper to the main duct leading to the registers. The exhaust fan draws the air from the ceiling registers back in the opposite direction through the distributing ducts to the exhaust fan.

A recirculating duct is also provided to recirculate part of the air in summer when the ventilating conditions are not severe. This cuts down the amount of refrigeration necessary for cooling the air, as the air being drawn out by the exhaust fan contains considerably less moisture than the outside air and, consequently, it is not necessary to condense as much moisture by this arrangement.

This system is designed to change the air in each room once every six minutes, which is adequate ventilation for all rooms when entirely filled. For ordinary use, however, at least one-half of the air can be circulated and still be well within the required limits of good ventilation.

All cold-air supply ducts are provided with a covering of cork board 1½ in. thick to prevent the collection of moisture on the outside and also loss of refrigeration.

Two small coat rooms are supplied from this system, the rooms being so small in comparison with the others that it was impractical to run separate ducts to them and provide each with its own set of mixing dampers for controlling the temperature. Branches were taken to them from the supply and exhaust duct to the entrance hall.

The coat rooms have a larger proportional amount of exposed wall and glass surface and therefore the temperature of the entering air would not be high enough to maintain their temperature at 70 deg. To compensate for this, an auxiliary indirect heater was placed in the supply duct to each room and the steam supply to the heater controlled by a thermostat placed in the room.

To determine the amount of radiating surface to install in these ducts, the following computation was used: The total heat loss from the entrance hall was first determined in the usual manner. The air change in this room was six times per hour. If the resulting temperature in the room is 70 deg., then

$$\frac{\text{B.t.u. loss}}{\text{Cubic contents} \times 6} + 55 = T - 70$$

where T is the temperature at which the air should be introduced. Applying this formula, T was found to be 88 deg. in zero weather.

The same formula was applied to the coat rooms, except 10 changes of air were used instead of six, which gave a required temperature of 108 deg. for the entering air. It was then necessary to put in radiation enough in the duct at the point where it entered the room to raise the temperature from 88 to 108 deg., or through a range of 20 deg. Referring to the tables given in the American Radiator

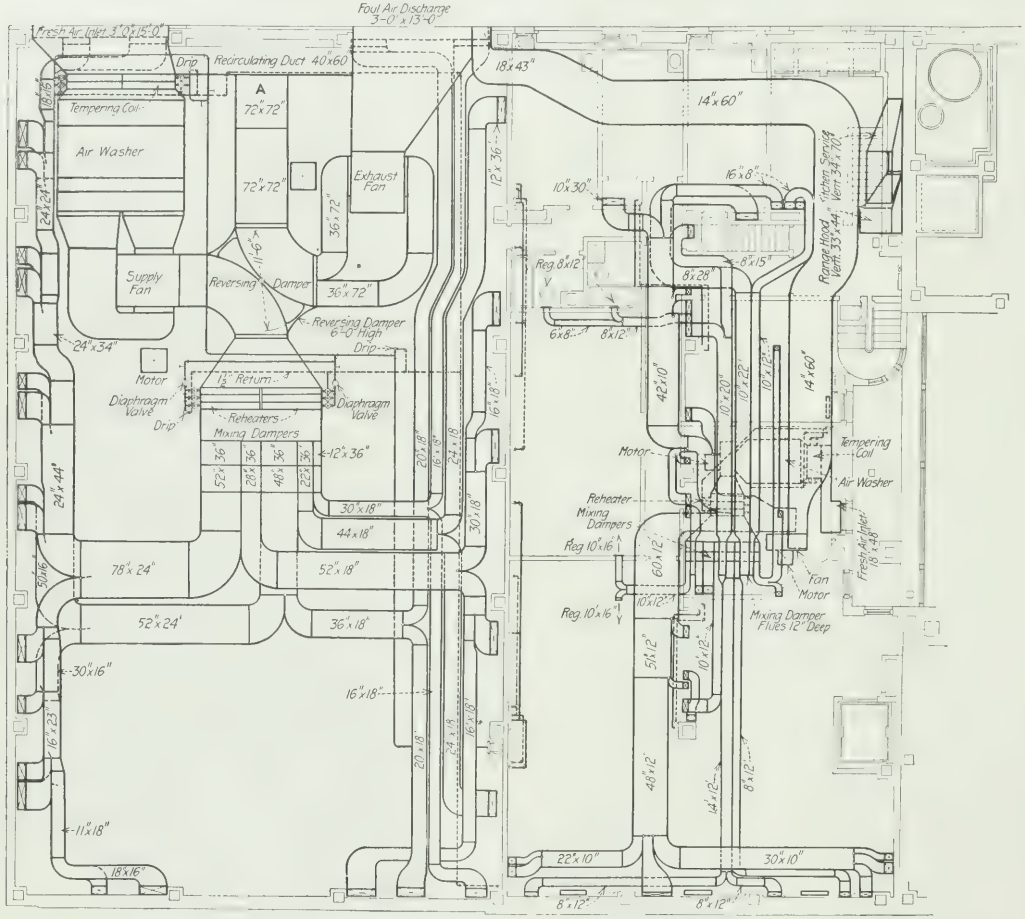


FIG. 1. LAYOUT OF HEATING AND VENTILATING SYSTEM FOR RITZ-CARLTON ADDITION

data book, it was found that with a velocity of 600 ft. per minute through the heater, which was the velocity of the air in the flue, one bank with sections spaced on 5¾-in. centers would give the required rise in temperature. Then dividing the total quantity of air by 600 gave the required amount of full area. The given free area through each section divided into this then gave the number of sections and the amount of surface necessary.

The toilet rooms are vented by means of one No. 9 multi-vane fan placed on the top floor and discharging to the atmosphere through a standard ventilator constructed of 24 oz. copper. Each toilet room has a register and duct leading to the main vent flue, the duct passing into the flue and up for a distance of about 3 ft.; in the vertical portion a controlling damper is placed. The top of each duct is covered with a tempering cap to prevent rubbish from falling into the duct during construction; after the work is completed, the caps are removed.

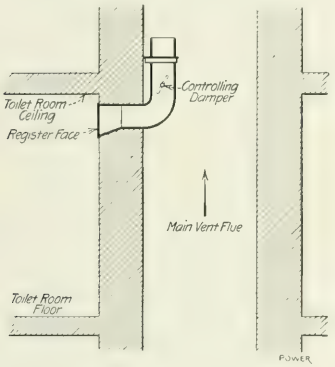


FIG. 2. SECTION THROUGH TOILET ROOM AND MAIN VENT FLUE

There are four of these main vent flues in various portions of the building, all of which lead from the first to the twelfth floor, where they combine into one main duct running in the hung ceiling over the hall and thence to the exhaust fan. In all toilet rooms throughout the buildings the air is changed once every four minutes. No fresh-air ducts are taken to the toilet rooms, but each room, whether it has outside exposure or not, has an inclosed direct radiator.

The circulation of steam throughout the building is produced by means of a vacuum system. Thermostatic traps containing a vaporizing fluid are used on the return of each radiator and heater and the inlet to each radiator is equipped with a graduated supply valve.

The original building was heated by a vapor system without the use of a vacuum pump. The main return was vented to the atmosphere in the boiler room and then passed through a loop seal to the feed-water heater. With the addition, however, two 8 and 14 by 16-in. vacuum pumps were installed and cross-connected, so that either or both pumps could work on either part of the building. The return from the new building was sealed with a loop and vapor pipe taken out from the return in the same manner as the old building. These pipes were provided with a shut-off valve and the connections to the pumps were taken from the bottom of the seal. With this arrangement, the vacuum pump could be cut out from either building and the system operated on the vapor principle.

The radiators in all the rooms are inclosed in recesses under the windows with registers at the bottom and top of the inclosures. The steam supply enters the radiators at the top through the graduated supply valve, and is so arranged as to bring the valve close up against the top of the inclosure. The valve stem extends through and the lever handle with the indicator is placed on the outside, where it is very accessible for the occupant to manipulate and obtain the amount of heat desired by hand regulation. A cross-section of this inclosure, illustrating connections to the radiator, is shown in Fig. 3. The forced-draft system of the plant will be described in a later issue.

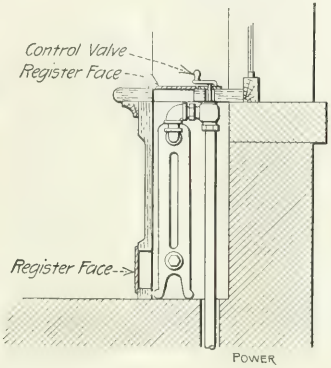


FIG. 3. INCLOSED RADIATOR UNDER WINDOW

The heating and ventilating system was designed by Clark, MacMullen & Riley, consulting engineers of New York City, and is being installed by the Cleghorn Co., of Boston, Mass.

The successful engineer is the man who, in addition to solving the purely mechanical problems, can make the dollar go farthest and draw out the best efforts of his workmen. Knowledge and study of the human factor bulk large in executive success.—*General Electric Review.*

An Isolated Plant Would Save $24,000

BY IRA N. EVANS

The paper read by Davis S. Boyden before the American Society of Heating and Ventilating Engineers and published in POWER of Feb. 27, is very clear and complete where the cost of the heating is concerned, but a little foggy when it comes to the contract rates for electric service in the stores of J. M. & Co., of Boston. However, by multiplying the area 637,800 sq.ft. by the rate $0.08436 given in Mr. Boyden's article and the cubic contents 8,391,000 cu.ft. by the rate $0.00641, the contract price for current is obtained as $53,805 and $53,786.31, respectively, for the year. Dividing $53,800 by the number of kilowatt-hours used per year gives 1.97c., or a trifle under 2c. per kilowatt-hour.

The reports to the public service commission of the New York district show that the cost of current, with all overhead and distribution charges included, for the New York Edison Co. is 3.16c. per kilowatt-hour. The cost of production for the Boston Edison must be considerably lower for the company to make a profit on a 2c. rate.

The manner in which the live steam for heating was manipulated during the test described is open to question, although the records as given check up with absolute accuracy. It should be noticed that the shortest day in the year, Dec. 20, was taken for the test. Department stores are generally lighted to a greater extent during the day than other buildings, but if daylight affected the load at all it would be boosted to the maximum on the winter solstice. The weather conditions and outside temperatures were a fair average for the heating season.

The method of conducting the heating test is open to criticism for the following reasons:

It is stated that the heating system of the Avon St. store, aggregating 11,000 sq.ft., or nearly 50 per cent. of the direct radiation, had been shut off from 6 p.m. to 12:30 a.m., when the test started. It is also stated that it was necessary to open all the air valves.

This indicates, and an analysis clearly shows, that the heating is shut off nights when the temperature is above 45 deg. outside. The writer has records which clearly show that nearly the same coal will be required, if the heating plant in a large building is shut down for 6 hr., to raise the temperature again, as would have been consumed if the heating were maintained continuously. This means that the coal would have to be consumed at double the rate for the shorter period in raising the temperature in the buildings. If the heating system of the Avon Street Building had been

operated for the previous 6 hr., about 4000 lb. less steam would have been used per hour from 1 to 7 a.m. Thus if the plant had been continuously operated, furnishing exhaust steam, the amount of coal for live-steam heating would have been materially reduced.

The glass and wall areas and transmission of heat of the radiation balance. The air supply when turned on at 8 a.m. shows practically the same steam requirements with the direct radiation included, as before the fans were started. See Fig. 3 of Mr. Boyden's article. In computation the following quantities will be used:

55,000 cu.ft. of air raised 1 deg. will require 1 lb. of steam.

1.7 B.t.u. will be used as the transmission for the direct surface per square foot per hour per degree difference.

222 deg. will be used as the temperature of the radiation at 3 lb. pressure.

24,000 sq.ft. is the number of square feet of direct radiation.

108,000 cu.ft. per minute is the amount of fresh air used for ventilation. It will be calculated to be raised to 70 deg. from the outside temperature.

The direct radiation will require

$$24{,}000 \times 1.7 \times (222 - 70) = 6{,}201{,}600$$

B.t.u. per hour

To heat the air for ventilation will require

$$\frac{108{,}000}{55{,}000} \times 60 = 118\ lb.$$

of steam per hour per degree rise in temperature.

The evaporation will be taken as 9 lb. per pound of fuel. From the Mar. 12 issue of POWER, Table 2 will be used to obtain the number of hours' operation for different periods of outside temperatures. The fans will be considered in operation during week days from 8 until 6 p.m., as shown by Mr. Boyden's article, or 1545 hr., which is equivalent to 154.5 days of 10 hr. per heating season.

Taking the latent heat as 964 B.t.u. and dividing, the average steam for heating the direct surface will be

$$\frac{6{,}201{,}600}{964} = 6430\ lb.$$

This will be the load on the direct radiation in average winter weather for heating during all periods, excepting those ranging between 50 and 60 deg. outside temperature. From the table the number of hours is found to be 3761.

There will be more steam used for periods 0-10 deg., 10-20 deg. and 20-30 deg. than for the average weather. From actual operating conditions on a plant the writer has the steam requirements as follows:

Outside Temp., Deg. F.	Lb. of Steam	Ratio	Per Cent.
0–10	16,500	165/112	147
10–20	14,760	1476/1120	132
20–30	12,960	1296/1120	116
30–40	11,200	112/112	100

The number of hours will be taken from Table 2 of Mar. 12 for these periods and added to the average steam consumption, 6430 lb. per hour, as 100 per cent.

Outside, Temp., Deg. F.	Hours	Excess, Per Cent.	Excess Steam, Lb. per Hr.	Total Excess Steam, Lb.
0–10	66	47	3020	199,320
10–20	264	32	2058	543,112
20–30	829	16	1028	852,212
				1,594,644

$$6430 \times 3761 = 24{,}183{,}230$$

$$24{,}183{,}230 + 1{,}594{,}644 = 25{,}777{,}874\ lb.$$

of steam per season.

The air supply will require steam as follows for periods of day operation, "A," Table 2, of the preceding issue:

Outside Temp., Deg. F.	Hours	Rise in Temp., Deg. F.	Lb. of Steam (118 Lb. per Hr. per Deg. Rise)
0–10	10	65	76,700
10–20	50	55	324,500
20–30	205	45	1,088,550
30–40	500	35	2,065,000
40–50	350	25	1,032,500
50–60	430	15	761,100
Total....	1545		5,348,350

The total steam for heating will be

$$5{,}348{,}350 + 25{,}777{,}874 = 31{,}126{,}224\ lb.$$

Assuming 9 lb. evaporation and 2000 lb. per ton of coal, the actual coal required for heating will amount to nearly

$$\frac{31{,}126{,}224}{18{,}000} = 1730\ tons$$

Mr. Boyden states that a kitchen and hot-water service is supplied. Allowing 12 per cent. for this service, the losses in radiation and vapor and the fact that New York temperatures are used instead of Boston with a 2-deg. difference in the average, the coal would amount to

$$1730 + 208 = 1938\ tons$$

or nearly the same as Mr. Boyden's figure of 1921 tons.

It may be noticed that this system of figuring steam for heating gives very close results when the variation in operating the plant and outside weather conditions for different periods is taken into account.

By dividing the coal in Fig. 3 of Mr. Boyden's article by 5 the kilowatt-hour load is found. It shows about 60 kw. from 5 a.m. to 8 a.m. and about 150 kw. from 12 to 5 a.m.

With high pressures and compounded a 500-kw. engine ought to show a steam consumption of 22 lb. per indicated horsepower-hour. Allowing 4 lb. for losses in the engine and generator and adding one-third more for a kilowatt-hour would give 35 lb. per kilowatt-hour at the switchboard. However, when operating on the heating, 40 lb. will be allowed and 35 lb. when exhausting to the atmosphere.

Figuring an evaporation of 9 lb. per pound of coal, Mr. Boyden's chart shows a requirement of 9000 lb. of steam per hour from 2 to 5 a.m. and 12,000 lb. of steam at 6 a.m. The room temperatures were constant at about 66 deg., and did not go to 70 deg. until the fans were started, with a rising temperature out of doors. Even after the fans were started the steam consumption remained at about the same point as the direct radiation, showing excessive work on the latter during the early morning hours.

When a plant is operating on live steam and a certain amount of work has to be done, it makes small difference when it is accomplished. Where a large amount of exhaust steam is available at certain hours and for a few hours at night the supply is insufficient, it would not be necessary to turn in live steam for a short period unless the weather was below 40 to 50 deg. out of doors. In considering the isolated plant, live steam will not be used for periods above 40 deg. For night operation there will be

$$60 \times 40 = 2400\ lb.$$

of exhaust per hour for 3 hr. and

$$150 \times 40 = 6000\ lb.$$

TABLE 1. LIVE STEAM FOR NIGHT HEATING

Outside Temp., Deg. F.	Time in Days	Steam, Lb. per Hr.	Steam Required over Exhaust from 150 Kw.		Steam Required over Exhaust from 60 Kw.		Live Steam Required, per Day, Lb.	Total Live Steam, Lb.
			Lb. per Hr.	Lb. per 5 Hr.	Lb. per Hr.	Lb. per 3 Hr.		
0–10	2.7	9450	3450	17,250	7450	22,350	39,600	106,920
10–20	11	8488	2488	12,440	6480	19,440	31,880	350,680
20–30	35	7458	1460	7,300	5060	15,180	22,480	786,800
30–40	61	6430			4030	12,090	12,090	737,490
								1,981,890

TABLE 2. LIVE STEAM FOR HOLIDAYS

Temp., Deg. F.	Hours	Steam per Hr., Lb.	Live Steam per Hr., Lb	Total Live Steam, Lb.
0–10	5	9450	7050	35,250
10–20	25	8488	6088	152,200
20–30	110	7458	5058	556,380
30–40	110	6430	4030	443,300
				1,187,130

of exhaust per hour for the 5 hr. from 12 to 5 a.m.

It will be necessary in determining the amount of live steam used for heating to find the number of days included for each period from the Table 2 previously cited when the temperature will be low enough to require it. Adding the percentage at the bottom of the columns for each period, the total time can be readily determined, also the hourly steam consumption by adding to the average the excess previously figured.

There will be ample exhaust steam week days for all purposes, but there will be requirements of live steam on Sundays and holidays, and it may be assumed that the load for power will be a minimum, or, say, 60 kw. and 2400 lb. of exhaust steam available.

Taking the hours from Table 2 of the Mar. 12 issue, "C" for holidays, and steam requirements as before, and adding 5 hr. of 0- to 10-deg. weather, the following results are obtained:

Adding the live steam for nights and holidays gives

$$1{,}981{,}890 + 1{,}187{,}130 = 3{,}169{,}020 \ lb.$$

per season. Dividing by the evaporation per ton of coal gives

$$\frac{3{,}169{,}020}{9 \times 2000} = 176 \ tons$$

per season. Subtracting from the total coal gives

$$1730 - 176 = 1554 \ tons$$

available for power. At 40 lb. steam per kilowatt-hour, 9 lb. of evaporation and 2000 lb. of coal to the ton the 1554 tons of coal will generate

$$\frac{1554 \times 9 \times 2000}{40} = 699{,}300 \ kw.\text{-}hr.$$

of electrical energy.

There are three 250-hp. boilers at present, and at 45 lb. of water per kilowatt and 1100 kw. as the maximum load, there will be required

$$\frac{1100 \times 45}{34} = 1456 \ hp.$$

in boilers. An allowance of 1600 hp. in boilers will be made, and deducting the present capacity of 750 hp. leaves 850 hp. additional to be installed. This should give a spare boiler under all ordinary conditions. A capacity of 1500 kw. in generating units should be sufficient. Allowing $30 per horsepower for the boilers, accessories and piping, and $50 per kilowatt for the generating units, with 10 per cent. interest and depreciation, will give the following expenditures in new equipment:

Engines and generators, 1500 kw. @ $50 =	$75,000
Boilers, etc., 850 hp. @ $30 =	25,500
	$100,500
Interest and depreciation, 10 per	10,050
Total	$110,550

According to Mr. Boyden's paper, 2,776,370 kw.-hr. of electrical energy were used on the premises during the year covered by the records. Allowing 40 lb. of water per kilowatt-hour would give

$$40 \times 2{,}776{,}370 = 111{,}054{,}800 \ lb.$$

of water as the annual amount used in the plant. Of this amount

$$1554 \times 18{,}000 = 27{,}972{,}000 \ lb.$$

is chargeable to heating and the balance of 83,082,800 lb. should be credited to the electrical plant. At 62½ lb. per cubic foot and $1 per 1000 cu.ft., the charge for water on the power end would amount to $1329. For labor additional to that given by Mr. Boyden, $4000 will be allowed. The amount of coal for power over heating may be found by deducting the 699,300 kw.-hr. previously determined, from the total given by Mr. Boyden. Thus

$$2{,}776{,}370 - 699{,}300 = 2{,}077{,}070 \ kw.\text{-}hr.$$

Taking 35 lb. of water per kilowatt-hour when exhausting to atmosphere, 9 lb. of evaporation and 2000 lb. of coal per ton, the number of tons of coal chargeable to the electrical plant is determined as follows:

$$\frac{2{,}077{,}070 \times 35}{9 \times 2000} = 4039 \ tons$$

At Mr. Boyden's figure of $3 per ton, this would amount to $12,117. Taking the cost of heating for the year at the amount given in the paper, $8582.29, the following summary on the yearly operating costs may be taken as approximately correct:

Heating as per Mr. Boyden	$8,582
Water	1,329
Extra labor	4,000
Coal for power over heating	12,117
Interest and depreciation	10,050
Incidentals	1,500
Total	$37,578

The cost of power and heating at present is

$$\$8582 + \$53{,}800 = \$62{,}382$$

and

$$\$62{,}382 - \$37{,}578 = \$24{,}804$$

represents the saving that would be effected per year by the expenditure of $100,000 for an isolated plant. For interest, 25 per cent. is not bad. It will pay a considerable rental on the space occupied by the plant and the owner would always be sure of a tenant.

Steam Heating Large Department Stores

I was interested in reading in POWER the reprint of the paper read before the American Society of Heating and Ventilating Engineers by David S. Boyden. It gives some interesting data on the cost of heating large department stores, and particularly the store of Jordan, Marsh & Co., in Boston.

It is apparent on reading the paper that the writer is very favorable to central-station service. While the figures and the charts are valuable, the paper is particularly interesting for what it does not state. For example: No comparison is made between the probable cost of making and the actual cost of buying electricity.

I learn from the paper that electricity was purchased at approximately 2c. per kilowatt-hour and that a total of 2,776,370 kw.-hr. was generated; that the cost of heating, including fuel, labor and all sorts of sundry supplies and repairs, was $8582.29, and this account is so carefully made that even oil and waste costing $7.35 are listed. But nothing is said about the cost of running the rest of the mechanical equipment! To what part of the operation are the services of the steamfitter, electrician, chief engineer and the elevator men charged?

The layman might add the cost of electricity to the cost of steam heat and figure that he had obtained the total cost of running the mechanical equipment of the building, and this would undoubtedly be the amount which would be compared with the actual cost of operating a private plant. Such a comparison would be unfair because the engineers of a private plant not only take care of the heating system and of the electric plant, but they take care of all these other items I have mentioned.

I do not find any charge for interest or depreciation in the cost of heating, for rental of space, for the manager's time or for the profit ratio, about which we have heard so much. I see no allowance for insurance or taxes. Surely all these are items of cost in operating the heating system, just as much as they are in the cost of making or buying electricity.

If we could get a detailed statement showing the total cost of operating the mechanical equipment of this store divided into labor and fuel and other items together with the space occupied by the boiler plant, pumps, refrigerating machinery, if any, cash blowers, etc., an interesting comparison might be made between the cost of operating this store and similar stores in New York.

I am not trying to depreciate Mr. Boyden's paper because the facts are extremely interesting, but I wish to bring out the fact that where a comparison is made between isolated-plant and central-station service, all the items entering into operating expense must be figured in both cases.

P. R. MOSES.

New York City.

In the Feb. 27 issue of POWER a mistake occurred in Fig. 2 of the reprint of my paper on "Steam Heating Large Department Stores." The May temperature shown by the dotted line should have been 62 instead of 72. The error was made in plotting the figures and will probably be obvious to most of the readers.

D. S. BOYDEN.

Boston, Mass.

Inquiries of General Interest

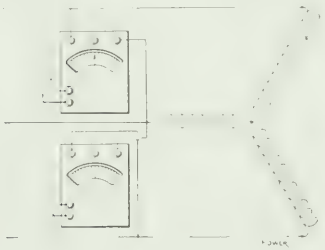
Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Measuring Unbalanced Three Phase Circuits

How can the power of an unbalanced three-phase circuit be measured?

J. P. F.

In unbalanced systems two wattmeters are required. Wattmeters give the quickest and most accurate results. The method of connecting is shown in the diagram:



MEASURING THE POWER, UNBALANCED THREE-PHASE CIRCUITS

The total power transmitted is the algebraic sum of the readings of the two wattmeters. If the power factor is less than 0.50, the power is the arithmetical difference of the readings, and if it is greater than 0.50, the power is the arithmetical sum of the two readings.

Horsepower Required for a Pump

What is the horsepower required to operate a pump of 10 in. diameter, 14 in. stroke, making 80 r.p.m., with a 156-ft. total head?

P. J. N.

First find the quantity of water to be handled by the pump. A cylinder 10 in. in diameter has an area of 78.54 sq.in. and in one revolution the piston will travel

$$2 \times 14 = 28 \text{ in.}$$

The volume of water passed through the pump per minute, if the piston and valves were tight, would be

$$\frac{78.54 \times 28 \times 80}{1728} = 101.8 \text{ cu.ft. per min.}$$

It is necessary to convert the cubic feet of water into pounds in order to obtain the foot-pounds of work done by the pump per minute. One cubic foot of water weighs 62.5 lb.; therefore

$$101.8 \times 62.5 = 6362.5 \text{ lb. per min.}$$

This amount of water is raised a distance of 156 ft.; consequently, the work done by the pump per minute is

$$156 \times 6362.5 = 992{,}550 \text{ ft.-lb.}$$

or

$$\frac{992{,}550}{33{,}000} = 30.08 \text{ hp.}$$

This is the theoretical horsepower required to raise the water through 156 ft. in one minute. If the overall efficiency is 50 per cent.,

$$\frac{30.08}{0.50} = 60.16 \text{ hp.}$$

would be required.

Stage Expansion Turbine

What is a stage expansion turbine?

M. V. B.

A stage expansion turbine is one in which the steam is expanded from initial pressure down to a certain point, and is passed successively through a set of revolving vanes and a set of fixed vanes. When the velocity due to expansion is expended, the steam is again expanded through another set of nozzles to a still lower pressure and the velocity is again extracted by passing it through another set of moving and fixed blades whose length and area are a little larger than the first. This operation is continued down to the terminal pressure by successive stages. With the larger machines as high as six stages are used.

Adiabatic and Isothermal Expansion

What is meant by adiabatic and isothermal expansion?

M. C. I.

When a gas in expanding and doing work does not receive from or deliver to an outside medium any sensible heat, and, consequently, its temperature is lowered in doing work, the gas is expanding adiabatically. For the same reason, if the gas does not transfer its heat or receive any except that produced by the work of compression, it is said to be compressed adiabatically. If a gas during expansion receives heat from some other source, equal to the amount expended in doing work, the gas is expanding isothermally and if it gives up all the heat of compression, it is compressed isothermally.

Speed of an Induction Motor

What is the rule to determine the speed of an induction motor?

R. M.

The speed depends on the frequency (cycles per second) and the number of poles in the field frame, and the slip due to the part of the load actually in use. The slip or difference in ratio of a rotating field or rotor is due to the resistance opposed to the rotor current. The slip will vary from 1 per cent. in a motor designed for close regulation to 40 per cent. in one designed for a special purpose. The rule may be expressed as

$$R.p.m. = 120 \frac{\text{frequency}}{\text{no. of poles}} \times (100 - \% \text{ slip})$$

British Thermal Unit

What is the correct definition of the British thermal unit?

R. G. P.

Marks and Davis define the British thermal, or heat, unit as $\frac{1}{180}$ of the heat required to raise 1 lb. of water from 32 to 212 deg. Peabody defines it as the heat required to raise 1 lb. of water from 62 to 63 deg. Rankine's definition is the quantity of heat required to raise the temperature of 1 lb. water 1 deg. F. at the temperature of its maximum density. The Marks and Davis unit is now widely used for engineering purposes, the heat of vaporation, or latent heat at 212 deg. F., being 970.4 B.t.u. Peabody defines the heat required to raise 1 lb. of water from 32 to 212 deg. F. as 180.3 instead of 180 units, and the heat or vaporization at 212 deg. F. as 969.7 B.t.u.

Heat Units per Ampere

How much heat is developed in a wire per ampere of current flowing through it?

R. W. O.

The heat developed is proportional to the watts, not the current alone. The watts lost are equal to the resistance of the wire × the square of the current. The expenditure of one watt in overcoming resistance develops 0.000948 heat unit per second. The relation between current and heat is as follows:

$3.413 \times Amperes^2 \times Resistance = B.t.u.$

The B.t.u. thus computed are heat units per hour.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71 Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Standardizing Flanged Fittings

In the past, engineers when laying out the piping details of power plants have often been seriously inconvenienced because of a lack of uniformity in the design of flanged fittings. Also, it was believed in some instances that the flanges lacked sufficient strength to withstand the stresses imposed.

With a view to standardizing the dimensions of flanged fittings and overcoming any inherent weakness in the design, a committee was appointed by the National Association of Master Steam and Hot Water Fitters to coöperate with a similar committee from the American Society of Mechanical Engineers, for the purpose of devising a schedule which, while overcoming existing faults, would strike a mean as to the practices of the various manufacturers. The results of the joint committee's work are embodied in a schedule which will be found elsewhere in this issue.

Before proceeding to definitely fix the dimensions given in the schedule, the committee earnestly sought the cooperation of the manufacturers, not only that it might benefit by their advice and experience, but in order that the changes might cause as little trouble to them as possible. We understand, however, that some of the manufacturers neglected to respond to this invitation and the preparation of the schedule continued without their assistance. Now that it has been completed and officially adopted by one of the societies concerned, several of the manufacturers are beginning to find fault with it, pointing out radical departures from their present standards, especially in the "center-to-face" and "face-to-face" dimensions.

In view of this opposition, it seems likely that there may ultimately be some changes in the schedule. However, as any action in this respect would take considerable time, we are giving the schedule as adopted and will advise our readers of any changes that may be made in the future.

Specifications

The tendency to purchase all power-plant equipment, fuel, oil and other supplies under specification is rapidly increasing. It should not be understood, however, that this tendency is caused entirely by lack of confidence in the manufacturer of such equipment or in the seller of fuel, supplies, etc. While there has been considerable unscrupulousness displayed—and is yet, for that matter—in the effort first to get the order and second to fill it as cheaply as possible regardless of quality and workmanship, this is the exception rather than the rule. In fact, the relations between the buyer and the seller are now such that the latter will usually accompany his proposal with specifications, drawings and guarantees so that there can be absolutely no misunderstanding after the contract has been placed. The reason for this can be attributed to his lack of confidence in the buyer just as easily where the buyer writes the specification.

The great difficulty now is the fact that many, if not a majority, of the specifications are written in a rather vague, indefinite way so that there are numerous loopholes for either party to crawl out if he so desire. If a specification is worth writing at all, it should be so written as to leave no doubt as to its meaning. In the first place, it should cover the ground thoroughly and include everything that the purchaser wishes to get. For example, it is hardly fair for him to insist upon getting without extra cost some additional instrument or regulator for his switchboard that happened to be forgotten in making up the detailed specifications. Even if the seller realized the necessity for such an instrument in the first place, he could not be held liable for any more than negligence in failing to advise the prospective purchaser of the fact.

Perhaps the greatest fault to find with many of the specifications is the use of such terms as "suitable material," "ample capacity," "highest class of workman-

ship," etc. These expressions are without meaning and, consequently, have no value. For instance, cast iron may, from one viewpoint, be suitable material for a certain part, whereas the purchaser prefers steel, thus resulting at once in a controversy. It often happens in such a case that the seller has based his price on cast iron, thinking it would answer the purpose very well. As to workmanship, there is probably a standard for almost every shop in the country and the highest class of workmanship in the one filling the contract would, no doubt, technically conform to the specification no matter how poor it might be. In this respect, however, a great deal depends upon the inspector, who can very often get the desired results by the use of a little diplomacy.

Last, but by no means least, comes the question of guarantee. After the full equipment has been received and properly installed, a test, or a series of them, if necessary, should be made in order to determine whether the machinery will properly and economically do the work intended. Many plant managers and owners think this is a needless trouble and expense and are satisfied to accept and pay for the material as received, provided it does the work, without any question being raised as to low operating costs. This is false economy and is often expensive. An exhaustive test for practically every important installation made is justified as it will not only determine the exact operating cost (and thus either show a saving or otherwise on the investment), but also it will often point out where some slight alteration in the general arrangement will make for even better economy or better operation.

Waste Coal in the Refuse

Some years ago the New York school board conducted a campaign of ash burning and reported that actual economy resulted from the treatment of the furnace refuse with a solution of salt and oxalic acid and then reburning it mixed with coal. The resulting economy in fuel, though not great, was just what might have been expected, not because of any latent virtue in the salt and acid solution nor because there was any possible source of heat in the ashes themselves, but because of the large percentage of unburned coal in the refuse which was returned to the furnaces to be consumed in the second burning.

Where the furnace refuse contains large quantities of partially burned coal, as is often the case in the careless operation of steam boilers, some low-cost method of recovering the unburned carbon is greatly to be desired. Screening and hand picking are usually too expensive to warrant resorting to this means. In sections of the country where the cost of coal is high, it is said that a process of "jigging" similar to that of separating ore from rock by gravity and agitation aided by a stream of water, is successfully carried out.

However, with properly designed grates and careful firing there is no excuse for any great waste of coal among the ashes. If the incombustible in the coal were ten per cent. and ten per cent. of the refuse consisted of partially burned coal, the actual amount wasted would be not more than one per cent.

Constructive Thinking

"Do not trouble your mind about details, but rather devote your time to constructive thinking." These instructions were given to the managers of a great industrial corporation by its head.

How would this work out if the chief engineer adopted it as a policy for the running of his department? Would he be justified in leaving the details to the care of his engineers while he busied himself with constructive thinking?

Is the competency of engineers of the rank and file such as to enable the chief to repose confidence in their ability to care for the details of operation? In some plants the chief could successfully carry out this policy, but there are many where he is compelled to remain at the plant fifteen hours a day, and then perhaps be called out of bed at three in the morning to put a crippled service into commission. This condition represents a deplorable loss of human energy, a waste of time and money and very often reflects a lack of proper interest on the part of his subordinates or the management.

Accidents are bound to occur, but their number can be greatly reduced by constant care and vigilance exercised by engineers and managers alike.

There are many industrial concerns which have introduced efficiency systems into the manufacturing of their products, but they have neglected to recognize the value of efficiency in the operation of their power plants. That the power plant is not classed as a productive division is no good reason why it should receive less consideration than those departments directly engaged in the production of the saleable goods. As soon as managers become aware of the possibilities for increased efficiency in this direction and find out that a saving or loss their is a saving or loss in the machinery of production, the power department will have come into its own.

It is the duty of a chief engineer to point out how this may be accomplished, and he will be able to do so if his subordinates are competent to take care of the details and give him the opportunity to think out the problems of operation—to think constructively. If the engineer will learn to read intelligently the charts from recording watt, volt, steam-flow and temperature meters and understand other means of obtaining available data, he can quickly locate the inefficient spots in the plant, and his department will without much doubt receive the attention it deserves at the hands of the management. To do this in a large plant, however, the chief must be relieved of the petty operating details, he must become a general and cease to be merely a maintenance man.

Education plus "overalls" equals a good operating engineer. This is a simple success formula, but many a college-bred man has been parachuted off the top of the theory ladder into the grime of the boiler room before he could get the correct answer.

The unsettled condition of the coal industry should furnish an incentive for the advocates of peat to prove its worth as a substitute for coal in those places where it is commercially available.

Regard no man as so inferior but that he can contribute to your fund of knowledge, says *Coal Age*. If nothing else, one can learn a lesson from his failure.

Vermont is the only state which had no boiler explosion in 1911.

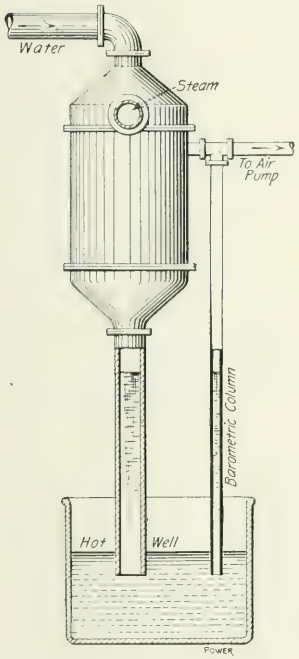
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Condenser and Steam Jet Froze

Following are two interesting instances of the troubles encountered in our plant during the recent excessively cold weather. Some may be inclined to be skeptical; nevertheless, they actually occurred.

I have a jet condenser, constructed something as shown in the accompanying



CONDENSER PIPING

illustration, that serves a 3500-hp. engine. There is a barometric column connecting into the line running to the air pump at a point just outside the condenser.

One day the condenser lost its vacuum for no apparent reason. Investigation showed that the water in the barometric column had frozen and that steam had condensed and frozen in this pipe, building up a column of ice that finally filled the pipe leading to the air pump, causing the vacuum to fail.

About the same time I had in use in one of the boiler houses steam blowers supplying forced draft to the boilers. On one of the cold days it was noticed that one of the boilers was not steaming well. The steam from the blowers had condensed and had built up a mass of icicles in the space surrounding the jets, practically cutting off the air supply.

To one not familiar with conditions here, where the temperature remained between zero and 15 deg. below for two weeks, these troubles may seem incredible.

J. F. MOWAT.

Joliet, Ill.

Oil Pipe Leaked

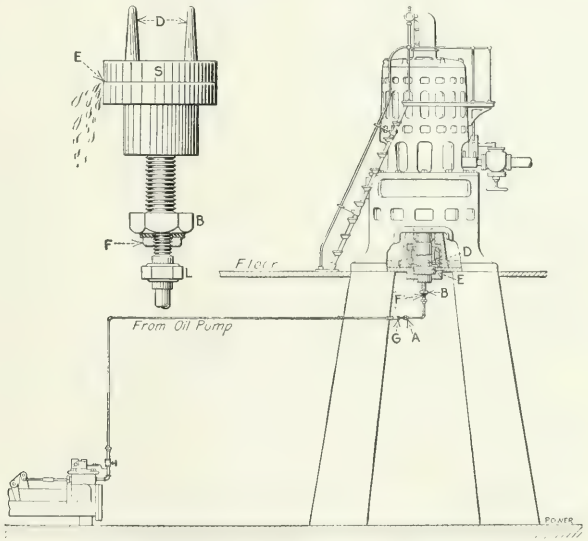
The oil feed pipe which screws into the bottom shoe of a step bearing in a vertical shaft steam turbine is often a source of trouble.

Several days ago the oil pressure dropped from 225 down to about 200 lb. per square inch. This was caused by the lowering of the steam pressure on the line and consequently the pump operated more slowly, which in turn lowered the oil pressure under the step, and both shoes naturally got a little rubbing.

The plant is not equipped to prevent these occurrences, so the men have to be on the watch. In this case it was necessary to remove the step and replace it with a new one from the shop.

After starting up, the pressure was maintained satisfactorily, except that a small leak developed where the feed pipe screws into the bottom shoe. The leak increased and upon opening up the union and removing the pipe, I found that it had been holding by two threads. I replaced and screwed it in as much as I could, giving it four complete turns, and thought that this would stop the leak, but the next morning it was leaking again.

For a remedy I devised a scheme that will be easily understood by referring to the illustration. At *F* is shown the leak; *A* is a union and *G* a baffle. I removed the short pipe *F*, threaded it and shortened it as shown in the enlarged drawing. Then I slipped a leather washer over the threaded portion of *F* and then a brass nut, which was screwed up tight against the bottom of the adjusting screw *B*. This made an excellent packing and stopped the leak.



WHERE THE STEP-BEARING OIL PIPE GAVE TROUBLE

To make things clearer, *D* shows the two pins which fit in the bottom of the turbine shaft. The revolving step plate S therefore is removable and in case of wear can be replaced. *E* is where the liquid comes out between the top plate and

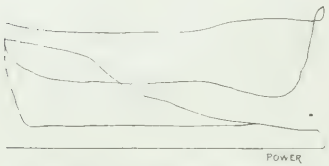
the bottom supporting plate. I have changed the union from *A* to *L*.

LUKE MARIER.

Fall River, Mass.

Freak Diagrams

The accompanying indicator diagrams taken from our Corliss engine may be



WHAT CAUSED THESE DIAGRAMS

interesting as freaks. Who knows what was the trouble?

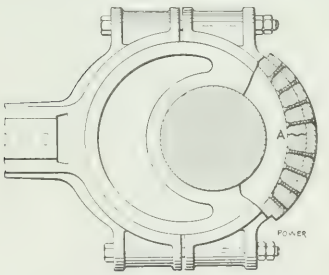
W. CLARK.

Penn Yan, N. Y.

Broken Eccentric Strap

While operating a locomotive crane, one of the eccentric straps broke in a peculiar manner at about the point represented by *A* on the drawing. This, of course, crippled the engine and needed immediate attention.

I forged out a steel band strap to fit on the outside of the broken parts; then I drilled four holes in the broken strap on either side of the break and drilled corresponding holes on the forged piece. The holes were countersunk on the in-



ECCENTRIC STRAP AS REPAIRED

side of the old strap and also on the outside of the forged band. The holes in the band were tapped with a $\frac{3}{16}$-in. tap and flat-headed stove bolts screwed tightly in place. The ends protruding on the inner side of the strap were riveted over as much as possible to fill the countersunk holes. A scraper was then employed to smooth off any protruding edges.

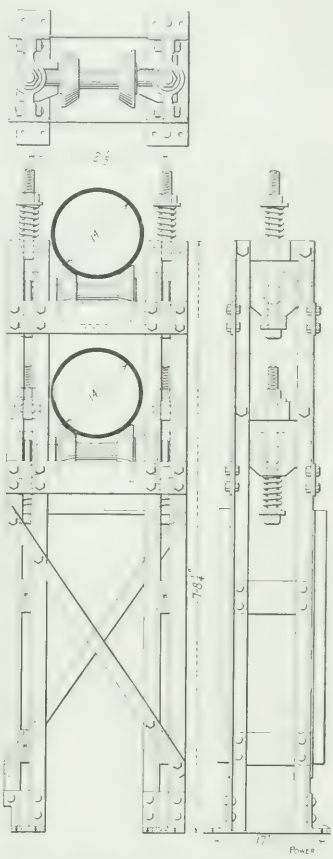
The strap was replaced and gave good service until the machine was abandoned for one of greater capacity.

F. F. SENGSTOCK.

Chicago, Ill.

Pipe Support

The accompanying sketch illustrates a support for two 14-in. high-pressure steam pipes. The pipe is situated so



DETAILS OF THE PIPE SUPPORT

that it expands downward horizontally and sidewise. The support takes care of the two 14-in. pipes, and is located in the center of the pipes which are 30 ft. long.

When finding the carrying capacity, the weight of the pipe plus the water in it was considered. The support serves its purpose in every detail, and avoids the leaky joints occasioned by the solid support formerly used.

R. G. Cox.

Milwaukee, Wis.

Raising the Boiler Pressures

In many cases it has been found that damage to property and loss of life have been caused by increasing the pressures of steam boilers.

This should be carefully considered before it is done, know that the boiler heads are braced sufficiently to withstand the increased pressure and that the longitudinal seams are of proper design. The strength of the entire boiler should be figured and allowance made for age and weak spots. The steam piping through the plant must also be examined.

I recently entered a plant which contained three 72-in. by 19½-ft. boilers and the plant looked safe and well laid out, but I soon noticed that a plate was fitted over the bonnet of the feed valve and that U-shaped bolts had been put around the body of the valve to clamp the plate down over the bonnet to hold it tight to the main body; other valves were also harnessed in the same way. I was told that a bonnet had let go some time before, as it was too light for the 120 lb. pressure which was carried.

When the plant was originally constructed a few years ago it was intended to carry but 85 lb. steam pressure, although the boilers were to carry 140 lb. pressure per square inch. The blowoff pipe was fitted with extra-heavy stop-cocks with a low-pressure gate valve between the stop-cock and the boiler. Both valves were neatly harnessed to prevent the bonnet from blowing out.

The pressure had been raised a few pounds at a time by each engineer as the load increased, from 70 lb. until the boilers were working under a 120-lb. head. On discovering the low-pressure fittings, the pressure was again lowered to 110 lb. per square inch. I think if more caution was taken in such cases fewer accidents would occur.

R. A. CULTRA.

Cambridge, Mass.

Lubricated the Steam Line

In the plant where I am employed trouble occurred from many leaks in the steam mains. As there was no time to shut down for repairs, I decided on a plan to stop them. There were about 40 leaks between the boiler house and the engine rooms, but today not a leak is to be seen.

No new gaskets were used, but the leaks were all stopped by feeding oil into the mains with two lubricators, one of which was made of an old trap, the other out of a 6-in. pipe, 4 ft. long. The oil was fed in as fast as the lubricator would work at the start, about 5 gal. every 24 hr. The more oil fed the quicker it will reach the joints and stop the leak, as it takes some time before the oil reaches all of the joints in a large plant, unless several lubricators are used, because the pipe must get coated first. At the present time we use 1 gal. of oil every 24 hr. to keep the lines well coated and prevent further leaks. It took about six months to stop the leaks.

When using oil it will first be noticed that the small leaks will disappear as the

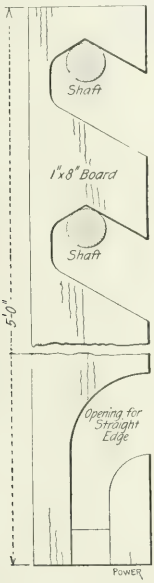
oil reaches the joints, and so on until the leaks have been stopped.

CHARLES H. GREENE.

Bath, Penn.

Shaft Aligning Device

The accompanying is a sketch of a home-made apparatus for lining up shafting. Nail two 1x8-in. boards together and saw them, as shown; then make a straight-edge about 8 ft. long. With this device one can align any shaft from ½



ALIGNING BOARD

to 5 in. in size. The two holes are so that if anything should conflict with the straight-edge it can be adjusted from one hole to the other.

ALLEN J. STOCKS.

Seattle, Wash.

Condensing versus Non-condensing

In a plant of approximately 30,000 hp., the chief engineer and the assistant say that five of the cross-compound engines, which are of 3000 hp. each, and are supposed to run condensing, will pull more load running noncondensing than they will when operating condensing. The chief also says that the funny thing of it is he cannot keep up steam when running noncondensing.

I have seen one of these engines deliver 5060 hp. to the switchboard before the condenser fell down, but how much would that engine pull now without the condenser? I cannot understand in what shape the valves are set to get the results the chief mentions, as when the vacuum is removed from the 64-in. low-pressure piston it is necessary to run the receiver pressure up to at least 30 lb., which puts an excessive back pressure against the high-pressure piston, cutting down the efficiency of that cylinder.

A man might just as well say that he can pull more load with a simple engine with 140 lb. of steam than he can with 150 lb. I do not know how the engineers feel about the balance of the plant. I wonder if they would do this same thing with a turbine.

C. L. JOHNSON.

Newark, N. J.

Caring for Hot Journals

Many and varied are the ideas for cooling a hot journal, but the main thing is to cool the journal without stopping the plant if possible.

The method I usually employ for a very hot journal is to first pour in some black cylinder oil, and if graphite is handy mix some with the oil. The heavy oil will lubricate—while an ordinary oil would simply boil—and if the shaft is rough the graphite will help to smooth it up.

I next slowly pour some clean, cold water through the oil hole onto the journal; I do not try to cool the journal all at once, I use the water and the cylinder oil and graphite alternately. This will usually produce a clean, cool journal.

If practicable, the cover and pedestal nuts may be eased to equalize the pull, if the journal is overloaded. By running the water through the journal it goes at once to where it is most needed and cools the inside and leaves the outside hot. The heavy oil forms a film on the shaft, and the water absorbs the heat.

I have tried sulphur, grease, white lead and castor oil, and if the journal is not very hot, these may keep it going and allow it to gradually cool down; but where there is a risk of shutting down, I prefer the cylinder oil, and it is usually at hand in a steam plant.

Using a heavier oil will help in a case like this. If the journal tends to heat, a good idea is to have an endless band hung over the shaft if possible, the lower end of the band running in a pail or tray of water. The band acts as an endless conveyor to lift the water to the shaft; this arrangement also keeps the place clean and gives no trouble.

It is advisable to examine an overheated journal at the first convenient stop and remove any brass dust or rough places on the shaft. If the shaft or bush is scored the journal should be draw-filed and polished; the brasses should also be touched up.

W. BURNS.

Govan, Scotland.

Grease for Valve Stem Bearings

One make of engine I operated had excessive travel of the various parts of the valve-gear, which necessarily caused more pin wear than would have been the case had the parts been properly laid out. The valve-gear wore more in the course of a year of steady running than a properly constructed gear should have in a ten years' run, the attention to lubrication and running being equal.

The engine was poorly equipped for lubrication. Even when carefully adjusted the governor spindle would wear down in the step bearing and it had to be set up once or twice in a summer. Oil would come to this bearing only from oil holes in the weight of the Porter style governor, through which oil was guided to the spindle.

Undoubtedly a great improvement was effected by running the governor gear in an inclosed box. The governor-pulley shaft was to run 127 r.p.m. and was only equipped with two small oil holes near the end of the bearing. These were replaced by a self-feeding cup in the center of the bearing.

The valve stems are a much neglected part of an engine. Even if an oil hole is supplied to each bearing, the hub of the bell crank sliding over the valve-stem bearing and oil hole in it is liable to cut off the supply of lubrication and take more than its share. As they are hot, on account of the proximity of the steam-valve port, I placed a grease cup in the hub of the bell crank, and also drilled four holes in the center of the valve-stem bearing and filed them out into one long slot. Now, no matter in what position the grease cup is, the lubricant will always drop down onto the valve stem.

I also cut an oil groove in the upper part of the bearing, on the inside, thus allowing the lubricant to spread over its length. Then I placed a grease cup on the wristplate and one on each exhaust-valve bearing, after taking out the small oil cups supplied with the machine, which were not large enough to give proper lubrication.

Due to these changes the engine has been kept in better shape with less attention than before the changes were made.

G. BERNA.

St. Louis, Mo.

The New York Public Library has recently organized a reference department containing catalogs of various manufacturers. This should be of great service to engineers as well as architects and contractors, and it is to be hoped that they, together with the manufacturers themselves, will coöperate in making this new department a success.

Diesel Engine at the South Pole

The "Fram," the ship in which Capt. Roald Amundsen sailed on his latest voyage of discovery to the South Pole, is propelled by a Diesel engine.

Capt. Amundsen selected this type of engine because the capacity of the "Fram" was too limited to carry a heavy burden of coal. With crude oil, the fuel of the Diesel engine, Capt. Amundsen was able to make a voyage longer by three to four times than with an equal weight of coal.

Four Men Killed in Boiler Explosion

On Mar. 7, at P. H. Gilpin's woodhandle factory at Greentown, Penn., a boiler explosion wrecked the plant, valued at $25,000, and instantly killed four men and seriously injured another.

Beyond the fact that the fatality occurred two minutes after the fifty employees had begun work in the morning, no further details are known and the cause has not yet been determined. An early account of the explosion will appear in POWER.

The American Society of Naval Engineers

The date of the annual banquet of the American Society of Naval Engineers was set this year upon March 9 that the occasion might be made commemorative of the battle between the "Monitor" and the "Merrimac." Walter M. McFarland, of the Babcock & Wilcox Co., speaking on "Naval Engineering from the 'Monitor' to the 'Oklahoma,'" told of the significance of that battle and its effect in making engineering paramount in the navies of the world. Hon. W. C. Redfield responded to the toast, "A Powerful Navy at once the Guarantee and Exponent of a Nation's Prosperity," Hon. Albert Estopinal to "The Navy and Congress," Hon. George von L. Meyer, secretary of the Navy, to "The Importance of Naval Engineering" and Hon. Joseph Cannon to "The Navy and the People." George H. Westinghouse and Col. E. D. Meier, two past presidents of the American Society of Mechanical Engineers, occupied places at the speakers' table. Capt. William Strother Smith acted as toastmaster.

Electric Propulsion to Be Tried by Navy

A system of electric propulsion will be given trial on the United States naval collier "Jupiter," which is under construction at the Mare Island navy yard in California.

In this system it is proposed to install one turbo-gtnerator running at a maximum speed of about 2000 r.p.m. and delivering current at 2300 volts to induction motors, one on each propeller shaft. The power from the turbine will thus be transmitted to the propeller shafts, electrically, with a speed reduction ratio of 18 to 1. The efficiency of transmission is expected to be about 91 per cent. The water rate for this installation is stated to range from 12.15 lb. per shaft horsepower at 14 knots, to 15.55 lb. at 10 knots.—*Engineering News.*

Considerations Governing the Selection of a Modern Steam Engine

The Harrisburg Foundry & Machine Works have issued, presumably for gratuitous distribution, a pamphlet bearing the above title. The water rate for four types of engine at 125 lb. initial pressure and atmospheric exhaust is given in the accompanying table.

Assuming that the engine runs 3000 hr. per year, 600 hr. at each of the given ratios of its capacity, the bulletin deduces that either of the compounds would be out of the question on account of their high water rate at the lighter loads; that with $3.50 coal the simple Corliss should be selected, but that with coal at $1.50 the saving might not warrant the increased investment over that required for a single-valve engine. A larger load factor would, of course, modify this conclusion.

STEAM PER INDICATED HORSE-POWER-HOUR, POUNDS

Type of Engine	Load ¼	½	¾	1	1¼
Simple single valve	35.3	30.2	28.5	28.1	28.4
Simple Corliss valve	32.4	24.5	23.1	23 6	24.7
Compound single valve	42.4	28.2	24.3	23.5	24.0
Compound Corliss valve	41.2	28.0	22.5	21.1	21.3

Annual Exhibit at Pratt Institute

The annual exhibit of the work of the evening classes in Pratt Institute will be held on Friday evening, Mar. 22, from 8 to 10 o'clock, and is open to the public.

The institute offers courses for men and women in drawing and design, applied art, applied science, sewing, dressmaking, millinery, household arts and various mechanical trades, and this exhibit affords an opportunity of viewing the work of the students, and of inspecting the results and methods as well as the school's equipment and general facilities for this kind of industrial training.

The work of the School of Science and Technology should prove of especial interest to men engaged in technical and trade pursuits, as it provides instruction in industrial electricity, technical chemistry, mechanical drawing and machine design, strength of materials, stationary engineering and power-plant machinery, machine work and tool making, carpentry and building, pattern making, sheet-metal work, plumbing, etc.

NEW PUBLICATIONS

CONSTRUCTION AND WORKING OF INTERNAL COMBUSTION ENGINES. By R. E. Mathot. Translated from the French by W. A. Tookey. Published by D. Van Nostrand Co., New York. Cloth; 550 pages, 6x9 in.; numerous illustrations and tables. Price, $6.

According to the subtitle, this is a practical treatise upon methods of construction, with calculations for the use of engineers, manufacturers and users, and a critical study of present-day types. The author further explains in the preface that his object in writing the book was not merely to present an exposition of the state of the art with respect to constructional details, this having been adequately accomplished in other recent publications; his purpose was to lay down "the precepts of theory and of practice as far as experience permits at the present day." Again, "he (the author) has reviewed the well known arrangements adopted by the chief gas-engine builders that in a sense have become standardized but, as far as possible, has avoided giving descriptions that have already been made public by several authors."

The average observant reader would undoubtedly have formed a much better opinion of the book if the foregoing prefatory announcements had been omitted, because the contents of the book are not in harmony with them. For example, in chapters IV, VI and VIII appear pictures of the Foos, Olds, Riverside, Warren, Stockport, National, Premier, Tangye, Ehrhart & Sehmer, Deutz, Körting, Nürnberg, Oechelhauser, Sargent and Diesel engines which are old, familiar friends, having appeared in many textbooks and most of the engineering periodicals years ago. The uptodateness of the book is rendered open to question by the inclusion of a two-stroke-cycle Buckeye engine which was built experimentally and abandoned three years ago, the Sargent engine, which has not been built for two years, the Rathbun engine with a valve-gear that was superseded about 2½ years ago, and several governor gears and ignition systems that were widely familiar ten years ago and became obsolete about four years ago. . Moreover, the reviewer is unable to find anywhere in the book the "critical study" promised in the subtitle.

However, chapter XII, on details of construction, is an excellent compilation of practical formulas and other data; chapter XIII, relating to moving parts, contains some very useful material, though mixed with a mass of partly

superfluous and partly perfunctory statements (for example: "No lateral movement of the flywheel [on the shaft] can be permitted; therefore, extreme care is required in keying to the shaft." Again: "The pistons for double-acting engines consist of (1) piston; (2) rod; (3) crosshead; (4) water-cooling system"). Chapter XIV, devoted to engine testing, also contains some highly useful suggestions, but it is laden with much more elementary discussion than is appropriate in a book of this class. The next chapter on indicator diagrams comes nearer being original than any part of the book, but the final chapter, on dimensions and classifications of engines and test records is the most valuable, because it presents some results of actual experience.

The book as a whole is characterized by a decided tinge of perfunctoriness—many words conveying little tangible information; where definite, clean-cut statements of opinion or observation are made, they are often so dogmatic as to be inapplicable to general cases.

THE TESTING OF MOTIVE POWER ENGINES. By R. Royds. Published by Longmans, Green & Co., London. 1911. Size, 5½x8¾ in.; 396 pages; 193 illustrations and several tables; cloth. Price, $3.

This book is intended for engineering students who have already acquired an elementary knowledge of motive-power engineering and who desire information on the practical testing of motive-power engines. The author hopes that the work will also be of service to the engineer in practice.

As it is well nigh impossible to touch upon every phase of motive-power engine testing in a single volume of this size, little or no attempt has been made to describe the mechanical features of the different types of engine or to interpret the action of an engine from a consideration of indicator diagrams as these portions of the subject are dealt with more or less fully in several textbooks. Numerous references are given for the benefit of those requiring a more detailed account of particular subjects.

The initial chapter deals with general principles, definitions, units, etc., and is introduced mainly for the purpose of reference. The subsequent chapters take up the measurement of pressure, temperature, etc.; the measurement of brake horsepower, in which several types of power brakes are illustrated and discussed; the testing of locomotives, motor cars, etc.; the testing of steam engines and turbines, boilers, condensers and air pumps, internal-combustion engines, gas producers; refrigeration tests; the testing of air compressors, air motors, etc., fans and blowers, water turbines and pumps.

In all cases, the basis of efficiency is defined and the formulas for ascertaining them are given. Particular attention is drawn to the variable conditions under which a plant may operate and the necessity for systematic arrangements where a series of tests are contemplated.

The book gives evidence of the author's thorough understanding of the subject and it may safely be recommended as complete and accurate.

MECHANICAL WORLD ELECTRICAL POCKET BOOK FOR 1912. Published by Emmott & Co., Manchester, Eng. Boards; 200 text pages, 4x6 in.; 80 illustrations; many tables. Price, 6d.

This year's edition of this well known little book contains some 16 pages more than the previous edition. These are divided up between the rewritten sections on motor starters, transformers, lamps, electric lighting, and aluminum conductors; a new section on testing high-tension apparatus, and some new tables on power factors, aluminum cables and carrying capacity of copper conductors. The sections on dynamos and motors, alternating-current systems, alternating-current machinery and electrical measuring instruments remain inadequate to the point of uselessness. The tables constitute the most useful portion of the book.

In a previous review it was erroneously stated that the book contained new sections on verniers and micrometers, roller bearings and other nonelectrical subjects; this error was due to having glanced through the mechanical pocket-book also, prior to reviewing this one, and thereby confusing the features of the two.

POWER PLANT TESTING. By James Ambrose Moyer. Published by McGraw-Hill Book Co., New York, 1911. Size, 6x9 in.; 422 pages; 271 illustrations and numerous tables; cloth. Price, $4 net.

This book seems to be little more than a compilation and a poor one at that. The subjects treated are of the usual list found in books on experimental engineering, and the reviewer has searched the volume in vain for one chapter that smacked of originality. Compilations have a very legitimate and useful function and, when properly made, they are of real value.

The trouble in the present case is that in some chapters useless material has been put in for apparently no other reason than that of filling up space, while in other chapters important material has been omitted. To illustrate: In chapter five there are two figures of and some text matter on Watt's original steam-engine indicator which might easily be dispensed with in favor of more elaboration in other directions. In chapter nine, on flue-gas analysis, space is given up to the description and illustration of an automatic instrument which has found but little, if any, application, in this country at least, while the author neglects completely to say a word about the Gas Composimeter, which is a widely used and most successful instrument.

Many of the illustrations are old friends; we have seen them before, in textbook, government bulletin and technical paper.

PERSONAL

George H. Smith & Co., of Baltimore, Md., have opened an office in the Munsey Building as consulting and contracting electrical engineers.

J. A. Struthers, formerly electrical engineer with the Westinghouse Electric & Manufacturing Co., Pittsburg, Penn., has accepted a position as designer for the Henry Manufacturing Co., New York City.

Barton R. Shoover, formerly electrical engineer for the Youngstown, Ohio, district of the Carnegie Steel Co., of Pittsburg, Penn., has been appointed superintendent of the new Brier Hill Steel Co., Youngstown, Ohio.

Charles E. Downton, representing the Westinghouse Electric & Manufacturing Co., recently lectured before the senior class of the College of Engineering of the University of Illinois, setting forth the advantages offered by his company in the matter of positions for technical graduates.

Prof. J. G. D. Mack, the exchange lecturer from the University of Wisconsin, gave two lectures before the students and faculty of the College of Engineering of the University of Illinois on Feb. 20. One lecture was on the engineering features of the Wisconsin Tax and Public Utilities Commissions. Prof. Mack is a member of the engineering staff of the commissions. The second lecture was on some features of ancient engineering work and their relations to present-day practice, and was, in part, an appeal to engineering students to study the history of engineering as well as current practice.

C. C. Owens has recently assumed charge of the Detroit district sales office of the Westinghouse Electric & Manufacturing Co., with the title of district manager. Mr. Owens was born in 1877 near Annapolis, Md., and was graduated from Columbian University, Washington, D. C., with the degree of bachelor of science in electrical engineering. He entered the employ of the company in 1896, taking the apprenticeship course for three years, after which he spent four years in the engineering department, specializing on switchboards and controllers. For the last eight years he has been connected with the New York sales office, having had charge of the industrial and power division for the two years previous to his transfer to Detroit.

Moments with the Ad. Editor

This week we are printing two more letters in answer to the questions asked in the issue of January 23.

The first is from Massachusetts and the second from far-off Italy.

POWER never makes much of a "holler" about its foreign circulation but it's there, as friend Peterson of the Richardson-Phenix Company would say, "with bells on and its hair done up in a braid."

We are especially glad that three of our subscribers in Europe answered the editorial of January 23.

It argues well for the interest in POWER advertising abroad.

H. W. Appleton says:

The J. M. Sea Rings Packing, to my mind, is the ad. most worthy of investigation. The rings seem to be built on a plan entirely original, and also appear the best thing yet for the purpose as the construction admits of the least possible gland pressure and friction on the rods. They are put out by a concern known to be reliable, and when my present supply of piston rod packing runs out I shall requisition a supply of Sea rings.

In the small industrial plant, fire-brick is a commodity purchased only at rare intervals, and usually the concern handling them in the locality where required gets the order regardless of quality. The Harbison-Walker people, however, have a way of showing views of the different processes in the manufacture of their brick which prove to be interesting as well as making a distinctive ad.

Consequently, when fire-brick are mentioned, I can at once see a picture of some of the different parts of their works. Therefore, their ad. may be said to have the best "storing-up" value.

The Nelson Valve ad. is the best, because it attracts the attention, is clear, descriptive, without being tedious, contains no knocks on other makes, and gives the impression of a high-grade product.

I have answered the Keystone Grease ad.

It is evident that the J. M. Sea Ring ad. made the impression that was hoped for by the writer of it. It is indeed a well designed and well written ad.—a regular Low and behold ad.! (F. J. please answer.)

Mr. Appleton's description of the Nelson ad. is good stuff—right to the point without a wasted word.

E. S. Wylde is mill manager for a well known Italian concern. He gets right down to business this way:

The Taylor Stoker ad. prompts immediate investigation because, although I am not the engineer of this concern, I am the mill manager, and this ad. has made me see in a way I have never realized before the enormous coal waste that must take place with black smoke being allowed to issue from the chimney, and therefore makes me wish to investigate it immediately and put an end to an ugly sight and save the money that is evidently being wasted.

The ad. of the Vance Steam Trap has the most educative value because the six advantages set forth in the ad. bring home to one the fact that a number of parts go to make the complete trap, and this helps to make one realize the need of educating oneself to understand and appreciate the countless parts that go to make the complete power plant.

To my mind the three great points in an ad. are: First, that it should catch your eye; second, that it should hold your attention; third, that after having read it, it should so recommend the thing advertised that one wishes to possess it.

Therefore, I consider the ad. of the International Textbook Company the best, catching one's eye as it does by its size and contrast with the next page, holding one's attention as one reads it, setting forth the advantages of "The Greatest Mechanical Library in the World," and thirdly, making one wish to possess it, covering as it does the whole field of mechanical engineering from raw materials to finished articles and their application

I answered the ads. of Albany Grease, the Taylor Stoker and the International Textbook.

If all ads. could be and were written to Mr. Appleton's prescription there would be less talk of advertising wastes and more of advertising profits.

Let us get the stuff into space that attracts, holds and convinces. Then we can all do business on the Albany Grease principle—with minimum friction.

POWER

Vol. 35 NEW YORK, MARCH 26, 1912 No. 13

NOT so many years ago, on the bank of most any Southern stream stood the negro log cabin; "razorbacks" rooted in the rich, damp soil, pickaninnies played or slept in the bright sunshine, and Uncle Eph'm just philosophized or temporized with his "prime mover" the mule—which moved when it had to and stopped when it could. And so did Uncle Eph.

Then, it was come-easy, go-easy, an' ole Missie done furnished de vittles!

Now, on every hand one sees manifestations of the development in the South; leisure has given way to progress; its lavish natural resources, including bountiful coal and iron deposits have been revealed.

Its manufacturing products amount to over a billion dollars annually; its exports to about four hundred million dollars. It has withstood tornadoes and devastations, and built up seaports which are the envy of the commercial world.

The prosperity of the South and its progress are mainly due to its equable climate and great natural resources. Its available waterpower is conservatively estimated to be equivalent to ten million horsepower and its coal deposits to contain over 600 billion tons.

That is a "lot" of coal.

If every one of the ninety million people in the country were capable of shoveling five tons a day, it would take them longer than three years, including Sundays and holidays, to "fire" this huge quantity.

The recent development of the city of Birmingham is somewhat indicative of the progressive spirit which pervades the "New South." In 1900 Birmingham had a population of 38,415; in 1910 the census returns showed her population to be 132,685, an increase of over 245 per cent. In 1900 eight and one-quarter million tons of coal were produced, while in 1910 over sixteen million tons were mined in and near that city.

We could go on and on, making one assertion after another and offering corroborative evidence, all to the effect that the South is the great country that it is. But, as the German comedian would say, "Enough is plenty."

Industrial growth must be accompanied by an increase in the number of opportunities for live, progressive engineers, for this is the age of mechanical power and, verily, industrial progress depends upon the motive power, be it water, gas or steam.

Elsewhere in this issue will be found a few practical instances of what has already been accomplished in power-plant development, of high-class engineering done under difficult conditions—of building to "stay put."

Combination Power and Ice Plant

By Paul C. Percy

A doubly composite plant in which both steam and gas are motive powers and the products are ice and electricity. The producers are fired with wood scraps.

The joint operation of an electric power plant and an ice-making plant has distinct advantages, provided the conditions are favorable, and this is more often the case than otherwise in Southern cities of moderate size, especially if the location is advantageous for the icing of refrigerator cars. Waycross, Ga., comes within this class. It is located on the main freight line between southern Florida and the rest of the United States and all fruit-carrying cars pass through it on the way to Northern and Central-western markets.

Being quick to recognize their vantage point, the managing officers of the Ware County Light & Power Co. have installed a thoroughly modern ice-making plant, with ample storage facilities, and are operating this plant eight months of each year in conjunction with the lighting and power plant which, of course, is operated continuously. The progressiveness of the management will be obvious when it is stated that the plant is operated 24 hours a day, except Sunday, although the town has a population of only 8000 and the day load ranges around 75 to 90 kw., according to the season; 24-hour service is not the rule under such conditions. To some extent, however, the operation of the ice plant conduces to the feasibility of maintaining day service from the electric plant—which is one of the advantages referred to in the preceding paragraph.

The company's station equipment is unusual, if not unique, considered as a combination. The prime movers are steam engines supplied by boilers fired with wood refuse burned in dutch-oven furnaces, and gas engines supplied by producers which gasify pine slabs, cypress stumps and roots, etc. At the time of the writer's visit, one producer was running on bituminous run-of-mine coal, but pine scrap alone had been used continuously for several months previous.

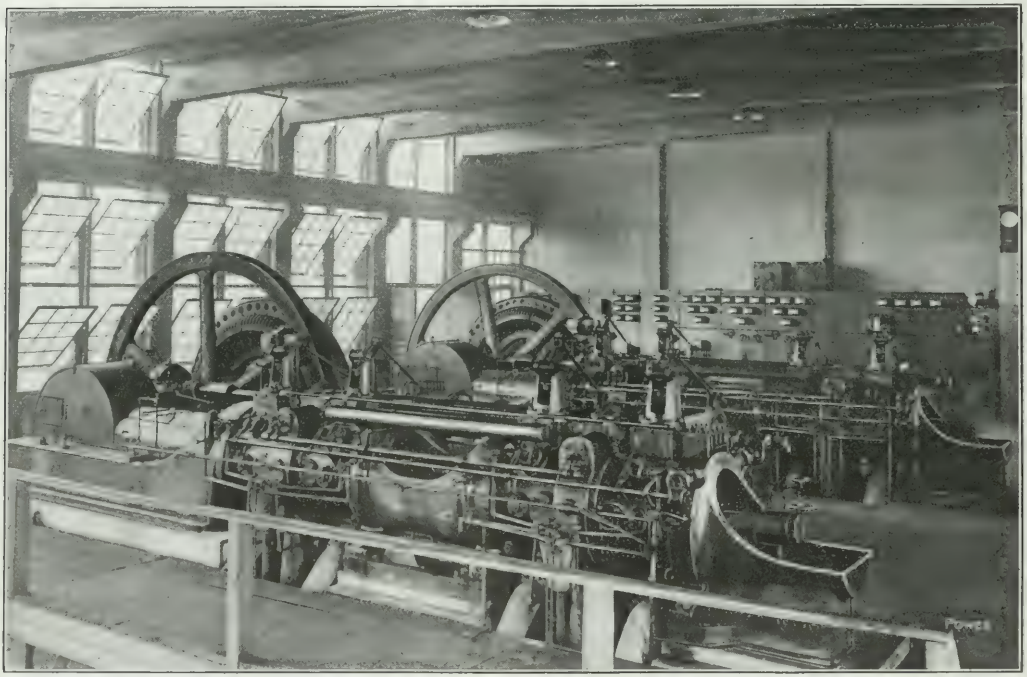


FIG. 1. VIEW IN THE ENGINE ROOM OF THE WARE COUNTY LIGHT & POWER CO.

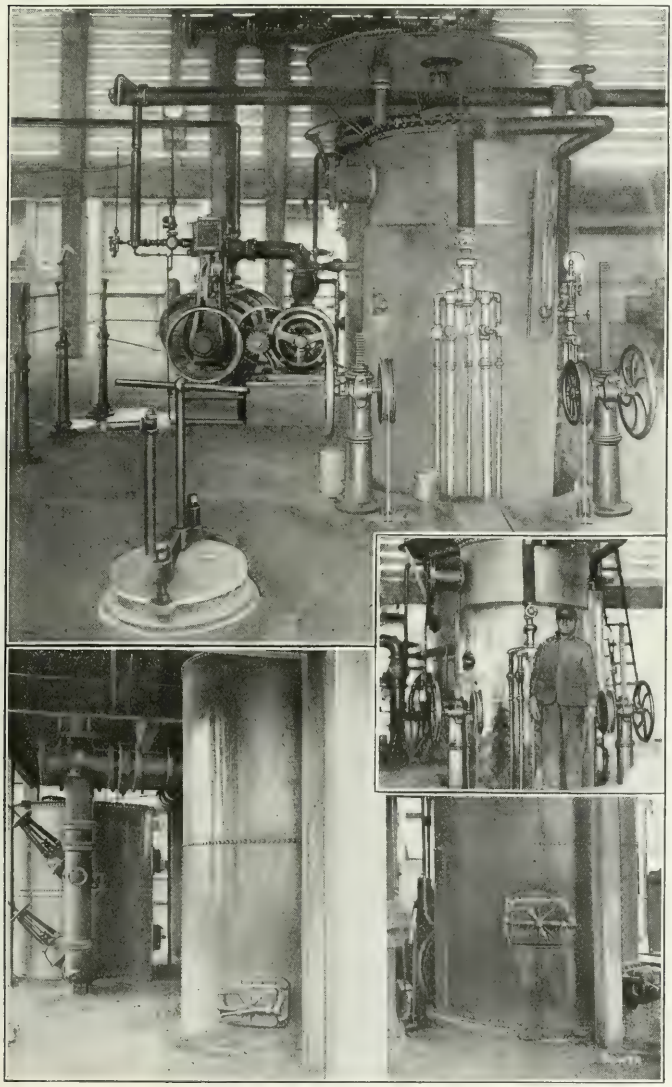
THE LIGHTING AND POWER PLANT

The gas-producer division of the plant is equipped with a 1000-hp. Loomis-Pettibone down-draft producer and a 750-hp. outfit of the same type. Each producer consists of the usual arrangement of twin generators serving through one wet scrubber and one dry purifier, and subjected to draft by a steam-driven exhauster. These make gas for two Allis-Chalmers tandem double-acting engines of 340 hp. each, running at 200 r.p.m. The engine cylinders are 18 in. in diameter and the stroke is 24 in. Each engine is direct-coupled to a three-phase alternator rated at 250 kilovolt-amperes and delivering its output at 2300 volts and 60 cycles. Each alternator has its individual exciter, belt-driven from a pulley on the main shaft between the engine frame and the alternator. There is also a motor-generator set as a reserve to be used in case of accident to either of the belt-driven exciters. This form of reserve unit for excitation was adopted because of the quickness with which it can be put into service.

Fig. 1 is a view in the gas-engine room and Figs. 2 and 3 are views of the producer charging floor; the latter picture illustrates very effectively the class of engineering talent that is available for operating power plants in this vicinity. Figs. 4 and 5 show portions of the producer cleaning floor.

The engine room is planned for the future installation of two more generating units similar to those now in service, and the producer equipment was installed with this ultimate capacity in view.

The exhaust gases from the engines pass through Riblet heaters which are located just outside the building, as shown in Fig. 6. The reason for this location was that it permitted the exhaust pipes of the engines to lead in a straight horizontal line from the engines to the heaters, thereby avoiding bends and intermediate pockets. The water heated by the exhaust gases is used for feeding the boilers of the steam plant and the economizers of the producer equipment. The location of the heaters out in the open air seems odd until one remembers that the climate is a mild one in winter and very warm during the remainder of the year. Moreover, the ice machines are not operated during the coldest part of the year and the water heated by exhaust gases is then only the relatively small quantity required by the economizers of the producer plant. Consequently, there is ample heat, even in the coldest weather which occurs down here.



FIGS. 2, 3, 4 AND 5. THE GAS PRODUCERS AND AN "ENGINEER"

The pine slabs and scrap used in the producers have a heat value of about 6700 B.t.u. per pound, as charged. The wood contains a considerable quantity of water, which, of course, reduces its heat value per pound much below what it would be with dry wood of the same quality. Thus far, however, the plant is lightly loaded, even during peaks, so that it would not be worth while to dry the wood before using it in the producer. The producer is cleaned once every six weeks.

During a recent run of 210 hours, close records were kept of the performance of the gas plant, which showed the results stated in the accompanying table. In considering the fuel consumption shown by the table it must be remembered that the engine in service operated with an average load factor of 34 per cent. and the generator with a power factor of 60 per cent. during three-fourths of each 24-hour day and the load factor during the remainder of each day was only 73 per cent. and the power factor 80 per cent. Under these conditions no apology is required for the producer ef-

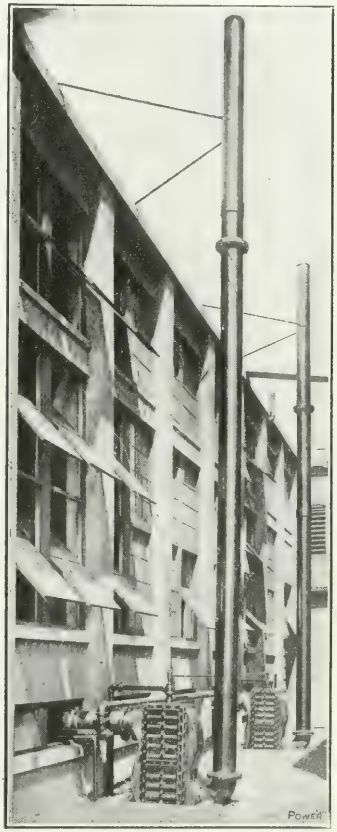


FIG. 6 EXHAUST HEATERS

ficiency of 69½ per cent. and the 14 per cent. thermodynamic efficiency of the generating unit. During a two-hour peak of 210 kw. load, the engine took 73,130 cu.ft. of gas, aggregating 6,581,700 B.t.u., showing a consumption of 15,671 B.t.u. per kilowatt-hour, or about 10,525 B.t.u. per brake horsepower-hour, accrediting the alternator with an efficiency of 90 per cent., which it probably did not have, taking into consideration the power required by the exciter. The gas made when firing wood shows about the following analysis:

CO	13.6%
H	12.75
CH_4	1.85
CO_2	12.00
O	0.40
N	59.40

By calculation, the low heat value is 101½ B.t.u. per cubic foot, reduced to 32 deg. temperature; the calorimeter values at the average temperature during the 210-hour run just reported were 90 low and 97 high.

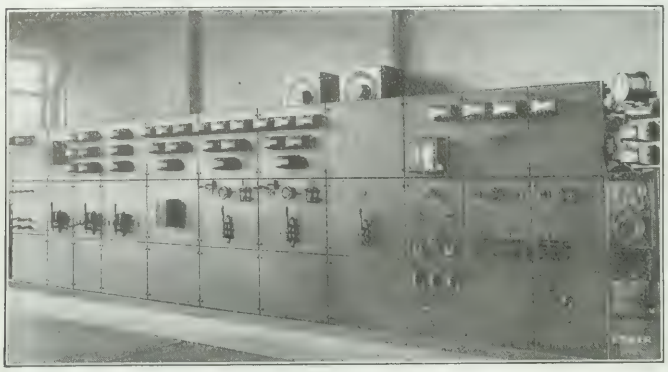


FIG. 7. THE POWER HOUSE SWITCHBOARD

RESULTS OF 210-DAY GAS-POWER RUN

Duration of recorded performance, hours	210
Total kilowatt-hours	21,280
Average load: day, 85 kw.; night, 183 kw.; overall	101.3
Total pounds of wood	120,300
Total cubic feet of gas made	5,770,900
Cubic feet of gas per pound of wood	48
Average B.t.u. per cubic foot (low)	90
Average B.t.u. per cubic foot (high)	97
Total B.t.u. delivered to engines (low)	519,381,000
B.t.u. per kilowatt-hour, average	24,400
Generating efficiency, per cent.	14
B.t.u. (high) in gas per pound of wood fired	4,653
B.t.u. (high) in wood per pound, as charged	6,700
Producer efficiency, per cent.	69½
Average power factor: Day	69%
Night	80%

THE ICE PLANT

The ice-making division of the plant comprises three return-tubular boilers rated at 150 hp. each, one 75-ton York compressor, one 30-ton Wolf compressor and a 6-ton Frick compressor, with the usual auxiliary equipment for making block ice. The boilers are equipped with furnaces of the dutch-oven type which are arranged so that they can be fired with either wood or coal, but are commonly fired with wood refuse. The two larger compressors are of the usual steam-driven types; Fig. 8 shows the York machine. The little Frick machine, however, is driven by a three-phase motor, because it is used only during the winter months when the steam plant is shut down.

From about Mar. 1 to Nov. 1, the steam-driven compressors are operated at full load and a storage house of 2000 tons capacity is gradually filled, in addition to the regular sale of ice locally and for icing refrigerator cars (this latter business disposes of 4000 to 5000 per season).

On Nov. 1 the ice-making equipment is shut down entirely and the 6-ton Frick machine is put into service to keep the temperature down in the storage house. The car-icing season is practically over then and the 2000 tons in storage fill the winter demand. On Mar. 1, the steam-driven compressors are started up again and the motor-driven machine is shut down until needed. It constitutes a modest excess-demand unit for emergency use at the height of the season, besides refrigerating the storage house in winter.

Running at full load, about 10 per cent. of make-up water is required in the ice-making system. It is the usual one in which the exhaust steam from the power cylinders of the compressors is condensed at atmospheric pressure, the condensate boiled again and filtered into the tanks.

The plant is operated under the very competent supervision of Mr. B. Loomis, Jr., to whom I am indebted for the foregoing information.

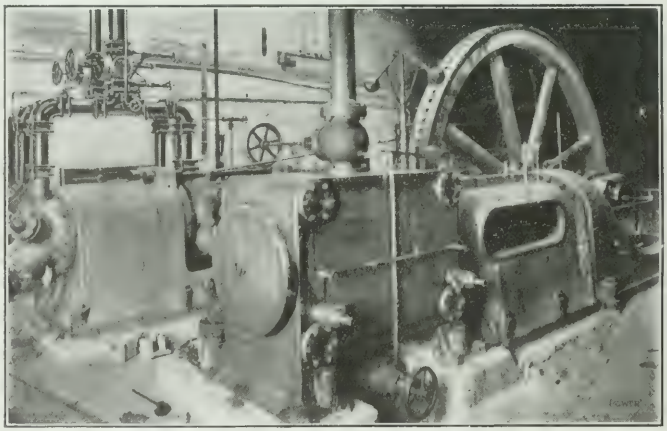


FIG. 8. THE LARGER ICE-MAKING MACHINE

Increase in Turbine Efficiency

The increase in turbine efficiency has been rapid and striking. A Parsons turbine of 4 kw. power, built in 1885, using saturated steam and working noncondensing, used 200 lb. of steam per kilowatt-hour. Another unit of 75 kw., built in 1888, using saturated steam of 100 lb. pressure and working noncondensing, required 55 lb. of steam per kilowatt-hour. Another turbo-generator of 100 kw. capacity, built in 1892 and using a condenser, brought the steam consumption down to 27 lb. per kilowatt-hour. A 1250-kw. turbo-generator, built in 1900, working with a condenser, lowered the consumption to 18.22 lb. per kilowatt-hour, and a 5000-hp. unit, in 1910, using 200 lb. of steam and 120 deg. of superheat, with a vacuum of 28.8, has reduced the consumption to 13.2 lb. per kilowatt-hour.—*Scientific American.*

Drainage Power Plant at New Orleans

By Cecil P. Poole

An uptodate central station, supplying about 5000 hp. to several pumping stations employing mostly synchronous motors to drive the pumps.

The low level of the city made this power drainage system necessary.

Because of the low level of the city of New Orleans with respect to the Mississippi River and neighboring lakes, the surface water deposited in the streets by rains cannot be disposed of by gravity. Therefore, a power drainage system was installed several years ago and this has been extended from time to time until now the power applied to the removal of water from the streets during a healthy thunder shower would be sufficient to operate the central station of a good-sized flourishing city. When everything is going at full load, the aggregate load on the system is about 5000 hp.

The drainage system consists broadly of a number of subterranean canals or conduits interconnected and opening into the near-by lakes, pumping stations containing large centrifugal and screw pumps, most of them driven by alternating-current motors, and a central power station equipped with steam-driven generating units which supply current to the pump motors.

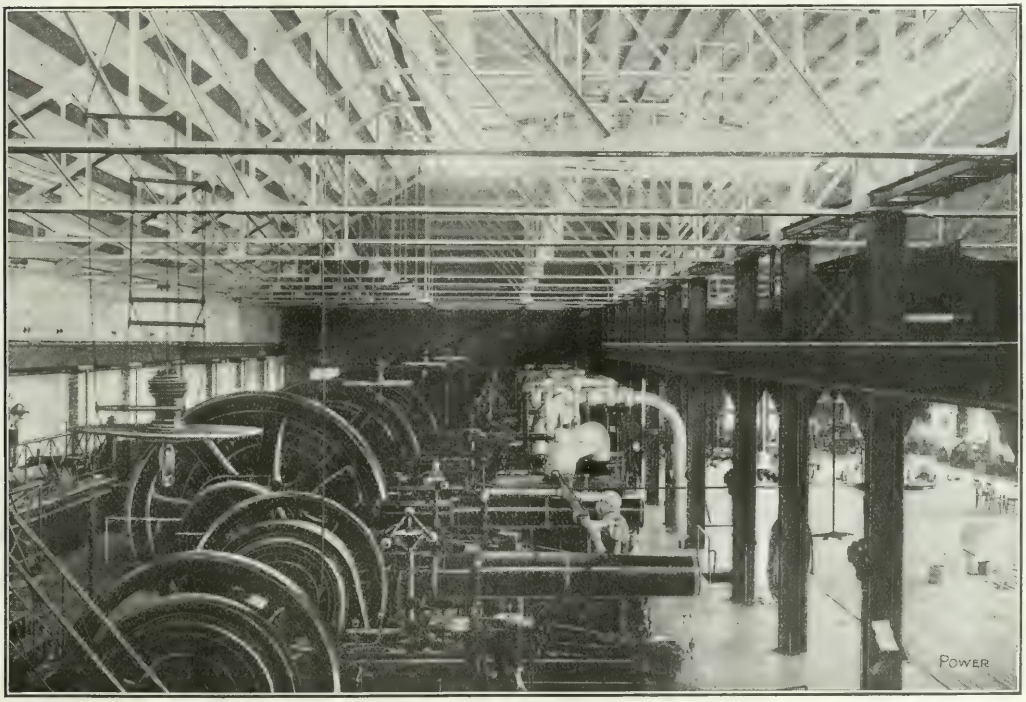


FIG. 1. CENTRAL POWER STATION OF THE NEW ORLEANS DRAINAGE SYSTEM

CENTRAL POWER STATION

The central power station is 182 ft. long and 140 ft. wide and houses Babcock & Wilcox boilers aggregating 2300 rated horsepower and Heine boilers aggregating 1100 rated horsepower, together with the usual auxiliaries; three cross-compound engines, each direct-connected to a 750-kw. three-phase alternator, another connected to a 1000-kw. alternator, a fifth cross-compound connected to a 375-kw. machine and two little tandem compounds each driving a 75-kw. generator. The exciter equipment comprises two 10-kw. steam-driven units and two 50-kw. motor-generator units, the motors of which are of the induction type. Fig. 1 is a view in the generator room of the power station. All of the engines are Allis except that of the 1000-kw. unit, which is a Rice & Sargent. All of the generators are of General Electric make.

The boilers are equipped with oil burners, as shown in Fig. 2, which utilize either crude petroleum or oil refinery waste products. Fig. 3 shows a sectional elevation and a cross-section of a burner, which is obviously of very simple construction. Oil is fed to the burners by two small steam pumps supplied from storage tanks into which it is pumped from the railroad tank cars in which it is delivered. No air is delivered through the burner; all of the air for combustion enters the furnace, which is of the dutch-oven type, from beneath, through ducts the entrances to which are controlled by dampers. Steam enters the mixing chamber through the central hole opposite the oil nozzle along with the oil and also enters through a hole above and one below the main jet, thereby maintaining ample pressure in the mixing chamber to give a good strong blast of mixed oil and steam out of the burner nozzle.

Crude oils from the Texas and Louisiana fields have been burned with these outfits; also refinery fuel oils, or petroleum from which the kerosene and lighter products have been distilled. This residue has an asphaltum base, but no difficulty has been experienced on that account. Without any special preparation or "tuning up," the boilers show an evaporation of 15 lb. of water, from and at 212 deg., per pound of oil or distillery residue; the heat value of the fuel ranges from 18,500 to 19,400 B.t.u. per pound of oil.

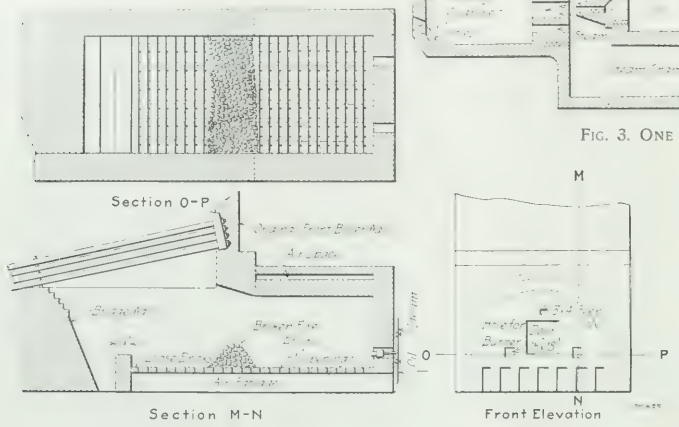


FIG. 2. BOILER FURNACE FOR BURNING OIL

The feed water for the boilers is obtained from artesian wells about 800 ft. deep. The water rises to within 25 ft. of the ground surface and is "lifted" from there to the boiler room by means of compressed air. It is excellent for boiler purposes, containing no material which forms hard scale; the principal matter in solution is carbonate of soda. On this account a general cleansing of the boilers is very seldom necessary; each boiler is simply emptied and refilled at intervals of about three or four weeks, because the water is alkaline and gradually becomes concentrated, but blowing out soft scale or sludge is very rarely necessary.

PUMPING STATIONS

There are now in operation seven pumping stations and an eighth will be built in the future. The accompanying map of the drainage system, Fig. 4, will serve to clarify the references to the locations of the pumping stations and their interrelations. Station No. 4 is the one that has not yet been built.

In most of the pumping stations the main pumps are set in pits, with the runners submerged, and are connected to their motors by vertical shafts, as indicated in Figs. 5 and 7. In the others, the pump shafts are horizontal and each entire pumping unit is mounted on the station floor level, as shown in Fig. 6.

Pumping station No. 1 is of the former class; it is a vertical section of this station that is shown in Fig. 5. The station contains at present three screw pumps, each driven by a 266-hp. synchronous motor and designed for moving 15,000 cu.ft. of water per minute with a 5-ft. lift from the level of the suction basin to that of the discharge basin; also a little centrifugal pump rated at 2400 cu.ft. per minute, which is driven by a 150-hp. induction motor and is used for removing the dry-weather water. Station No. 2, located at Broad and St. Louis Sts., is similar in all respects to station No. 1 except that it is equipped with two large screw pumps instead of three. It drains the area bounded by the two navigation canals, the Mississippi River and Broad St.

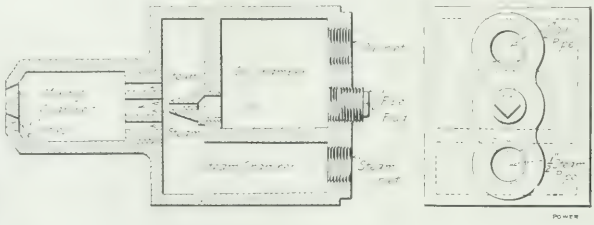


FIG. 3. ONE OF THE OIL BURNERS

Pumping station No. 3, located at Broad St. and London Ave., at present contains three centrifugal pumps, of which two are driven by 400-hp. synchronous motors and are capable of moving 15,000 cu.ft. of water each per minute, with an 8-ft. lift, and the third is

FIG. 4. MAP OF NEW ORLEANS DRAINAGE SYSTEM

rated at 3000 cu.ft. per minute with a lift of 12 ft.; this one is driven by a 120-hp. induction motor. These pumps all have horizontal shafts and are located on the floor level of the station, as shown in Fig. 6, which is a sectional elevation of this station. The pumps are primed by means of a small vacuum pump, driven by a direct-current motor, after they have been brought up to normal speed and the starting compensators are cut out. This arrangement makes it very easy to start the pumps and accelerate their motors to synchronism; moreover, no gates are necessary in the intake and discharge pipes, because these are drained by gravity as soon as the pumps are shut down.

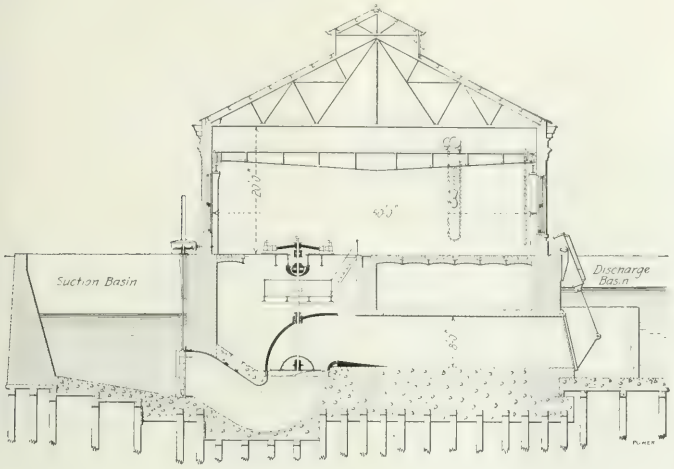


FIG. 5. SECTION THROUGH PUMPING STATION NO. 1

The pumps in station No. 5 were originally driven by 400-hp. vertical triple-expansion engines, but when station No. 8 (in Algiers, across the river from New Orleans proper) was added to the system one of the engines was transferred to that station and a 333-hp. synchronous motor was installed in its place. Station No. 5 therefore contains now one pump direct-connected to the remaining steam engine and one electrically driven. The steam unit is not used except in cases when abnormal rains carry the load beyond the capacity of the motor-driven pump. The pumps have horizontal shafts and are located on the station floor level as in station No. 3. Each one is capable of moving 9000 cu.ft. of water per minute, with a lift of 12 ft. They are of the double-suction centrifugal type.

Station No. 6 is the largest one of the system. The present equipment consists of four centrifugal pumps, each capable of moving 15,000 cu.ft. of water per minute with a lift of 10 ft. and one rated at 1800 cu.ft. per minute with a lift of 13½ ft.; all of these pumps are of the vertical-shaft submerged type. The large ones are driven each by a 466-hp. synchronous motor. Each intake and discharge pipe is provided with an 8-ft. sluice gate operated by a small electric motor and each discharge pipe is also provided with a flap gate (see Fig. 5) which acts as a check valve and closes the outlet when the pump is shut down. This, obviously, prevents the backing up of water from the discharge basin when the pump is idle and thereby avoids the possibility of having to pump the same water twice. The smaller pump is driven by a 100-hp. induction motor. Station No. 7, located at Orleans St. and Taylor Ave., is exactly like No. 6 except that it contains three pumps instead of four.

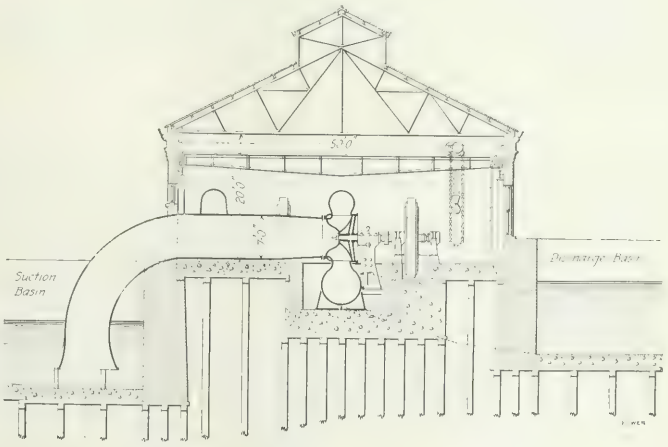


FIG. 6. SECTION THROUGH PUMPING STATION NO. 3

Station No. 8, in Algiers, contains one centrifugal pump of the horizontal-shaft type, driven by the triple-expansion steam engine which was removed from station No. 5. The pump is rated at 9000 cu.ft. per minute and the engine at 400 hp.

STARTING THE SYNCHRONOUS MOTOR PUMPS

Those motors which are located on the station floor levels are readily started, brought up to synchronism and thrown into service, because the runners are not submerged and the motors can be started with the pumps empty and brought up to synchronism with practically the same facility that characterizes starting a motor entirely disconnected from its load. After attaining normal speed the load is applied by priming the pumps by means of small pumps driven by induction motors.

With the submerged pumps the starting and acceleration of the motors are much more troublesome, because a synchronous motor will not start with a load; its torque, starting inductively, is too feeble. Therefore, it is necessary either to empty the pumps of water and start in the same way as with the floor-level pumps or else to slow down the generators at the central station until the frequency is low enough to pick up the motor with its load on and then accelerate up to normal frequency.

This latter method is the one now used, the starting of a motor, or of all the machines in a station, being accomplished by connecting up to a single generating unit at the central power station, through busbars separate from the general system. The generating unit is slowed down until the frequency is about 15 cycles, the motor switch is closed and the machine brought up to the gen-

erator frequency without the compensator commonly used for starting without load. Then the generating unit is gradually accelerated to the normal speed, carrying the motor along with it. When normal frequency has been attained the generator is shifted over to the regular running busbars and the extra busbars are free for starting another motor or group of motors with another generating unit.

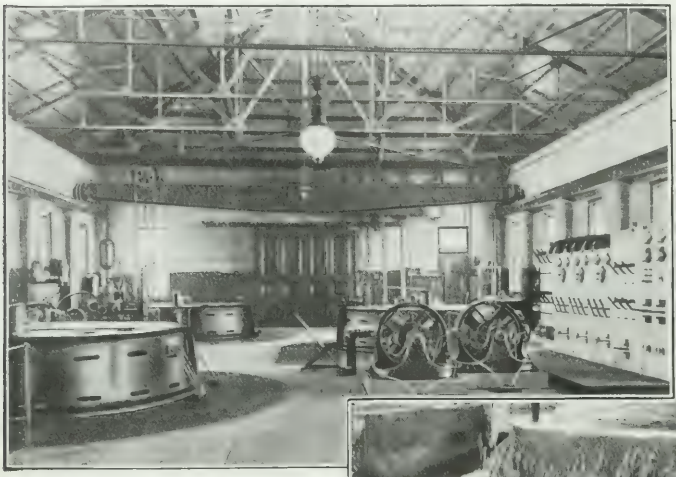


FIG. 7. INTERIOR OF STATION 7

This method has grown to be rather unwieldy with the growth of the pumping equipment, and arrangements are under way for installing small pumps and induction motors to be used for pumping the water out of the housings of the submerged pumps and thereby allowing them to be started up free, at normal frequency, as the elevated pumps are now started.

Ten more pumps are to be added to the system in the immediate future, each to have a capacity of 30,000 cu.ft. per minute. All of these will be of the horizontal-shaft form, located above water level, and the motors will be started at normal frequency with the pump runners empty.

TRANSMISSION LINES

Each pumping station except No. 8 is connected to the central power station by means of two distinct feeders, and each feeder is protected by an ample equipment of multigap lightning arresters, located about half a mile apart. The lines are supported on cypress poles set 9 ft. into the ground and projecting as short a distance above ground as possible without interference with street traffic. No transformers are used between the central station and the pumping-station busbars. The generators deliver three-phase currents at 3300 volts and the motors are supplied directly at that voltage.

Power from a Small Low-Head Stream

BY S. RICE

The Athens Ry. & Electric Co., of Athens, Ga., operates three hydro-electric plants on the Oconee River, located respectively at Mitchell's Bridge, Tallassee Shoals and Barnett Shoals, aggregating in capacity 5200 kw.; also a steam-turbine auxiliary station of 1500 kw. capacity located in the city of Athens. The latest of these installations is the plant at Barnett Shoals, Fig. 1, which has recently been put in service. It was built by the James White Power Co. and leased to the above named public-service corporation for 99 years.

In this plant, which was designed for a net effective head of 50 ft., the most modern features of construction for utilizing the full available power of the stream have been embodied. It is, in fact, an excellent example of the possibilities of power generation to be developed by good engineering from the flow of a small stream with only a moderate head.

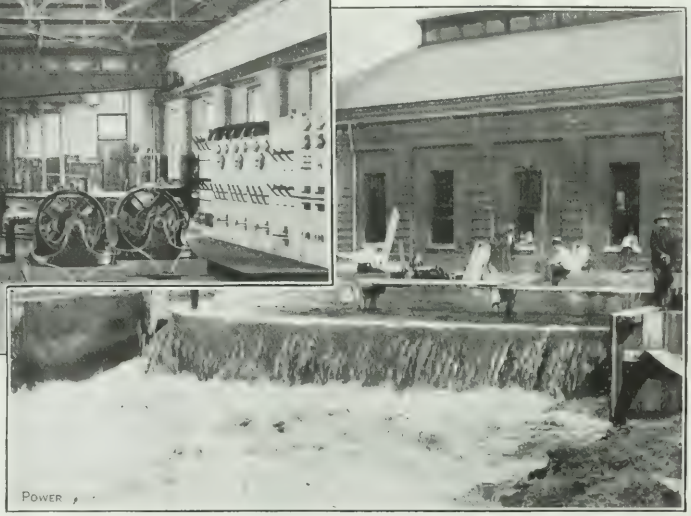


FIG. 8. TEST AT STATION 1; ONE PUMP DELIVERING 15,000 CU.FT. PER MINUTE

Fig. 2 is a plan of the station and Fig. 3 is a longitudinal section through one of the generating units. The four hydraulic turbines are of the twin-runner, horizontal open-flume type, with center-discharge casings. Each is rated at 1200 h.hp. when running at 360 r.p.m., under a

FIG. 1. BARNETT SHOALS POWER HOUSE OF THE ATHENS RY. & ELECTRIC CO.

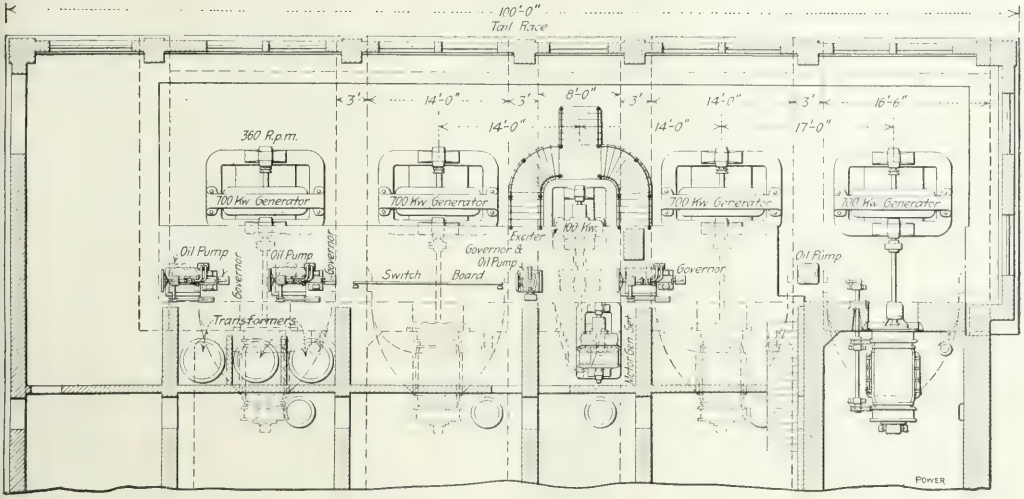


FIG. 2. GENERAL PLAN OF STATION

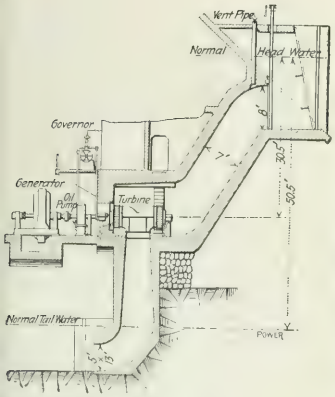


FIG. 3. SECTION THROUGH PLANT

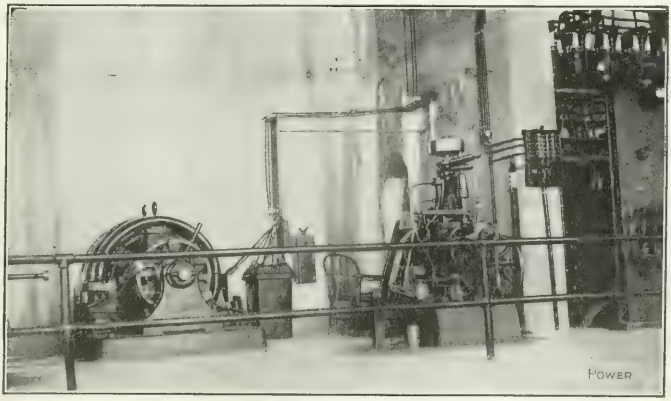


FIG. 6. SELF-CONTAINED GOVERNOR FOR EXCITER TURBINE

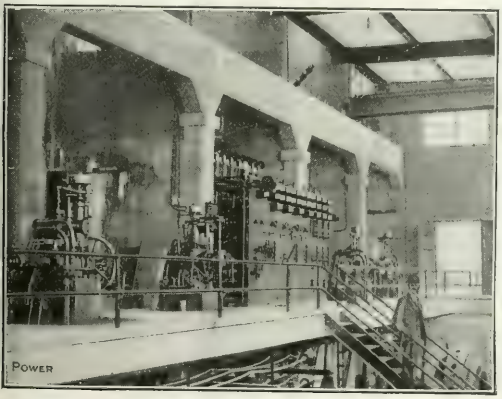


FIG. 4. OIL-PRESSURE GOVERNORS AND SWITCHBOARD

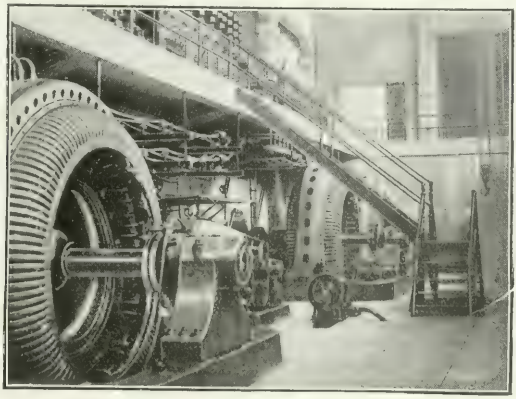


FIG. 5. MAIN GENERATORS

50-ft. head, and is direct connected to a three-phase, 60-cycle, 12,000-volt generator of 700 kw. normal capacity.

The governors for these turbines, Fig. 4, are of the oil-pressure type, each consisting of a stand with fly-balls, relay and regulating valve and also a regulating cylinder, together with a separate rotary gear-type oil-pressure pump. The pressure tank is mounted directly on top of the pump housing. These governors operate with the open oil system; that is, after it is used in the regulating cylinder, the oil is returned to an open receiving tank, where it has a chance to settle and clarify before returning to the rotary pump and pressure tank.

There are two exciter units, each of 100 kw. capacity, furnishing direct current at 120 volts. One of these, used for starting, is driven by a direct-connected hydraulic turbine of the single-runner, horizontal, quarter-turn-discharge type, rated at 210 b.hp. Its governor is also of the oil-pressure type; but in this case the rotary pump, regulating cylinder and fly-ball stand are all included in one self-contained unit. The second exciter, of similar characteristics, is driven by an induction motor. This also appears in Fig. 6.

The outgoing three-phase lines to Athens are provided with protective devices consisting of choke coils, aluminum lightning-arresters with horn-gap disconnecting switches, and other apparatus.

In the generating plant there is also a substation for an industrial power circuit. This includes the three 12,000/2300-volt oil-insulated, self-cooled transformers.

The Athens Ry. & Electric Co., in addition to its traction and lighting load, furnishes power for motor drive in a number of large textile mills and other manufacturing establishments, one cotton spinning plant being located near the power site. The operation is in charge of C. D. Flanigen, second vice-president and chief engineer, and C. L. Proctor is superintendent.

The Causes of Boiler Explosions

By S. F. Jeter*

A paper delivered before the American Boiler Manufacturers' Association at New Orleans, Mar. 12 to 15. The chief causes of boiler explosions are assigned as poor design and carelessness in operation. These are considered somewhat in detail, together with recommendations tending to reduce the number of explosions.

*Supervising inspector, Hartford Steam Boiler Inspection & Insurance Co.

Broadly speaking, there is one explanation for all boiler explosions; namely, the boiler or some part of it is too weak to withstand the stress brought upon it. There are many causes contributing to such weakness, and a definite cause can usually be given for most explosions.

Public opinion is being aroused to the fact that many boiler explosions are preventable, as evidenced by the present agitation for laws governing the construction and operation of boilers. The lead of the city of Philadelphia has been followed and improved upon by the state of Massachusetts; also Ohio and several municipal governments now have boiler laws patterned after those of Massachusetts, and similar action is being considered seriously by a number of other states and cities.

Faulty Design

One cause of boiler explosions is faulty design, as they are frequently constructed too weak for the pressure to be carried. This does not mean that the boiler will necessarily explode as soon as the pressure is raised. Explosions from this cause usually occur after years of use, the overload on the parts having had time to gradually weaken them until they are no longer capable of resisting the excessive strain.

Of course, a manufacturer has practically no control over the steam pressure to be used on a boiler, after it has been delivered to the purchaser. But if the manufacturer should stamp his name and the safe working pressure for which it was designed on each boiler built, it would act as a protection to his reputation in the event of excessive pressure being used. Proper inspection and fixing of pressures by experts is the logical remedy for explosions due to this cause.

A fault of design which often leads to an explosion is the adoption of a shape which tends to deform under pressure. In such cases, if the movement produced occurs within narrow limits along fixed lines, grooving or cracking is almost certain to occur, finally resulting in an explosion, unless the defect is discovered before the structure has been weakened to the breaking point. The obvious remedy is to use shapes which the internal pressure does not tend to change, and if this is impractical, to use such forms that the movement produced will occur over considerable areas and not be confined to narrow limits.

Improper reinforcement of openings has occasionally been the cause of boiler explosions. If the openings in boiler work were not generally of such moderate dimensions, this might be a more frequent cause of disaster. No definite information is available regarding the distribution of stresses around an opening in a cylinder when subjected to internal pressure; consequently, the design for the reinforcement of such openings is by rule-of-thumb.

Another fact responsible for many explosions is an arrangement not permitting of accessibility for the inspection of all parts. This is especially so when the inaccessible parts are located where rapid deterioration is likely to occur. No portion of the boiler proper should rest directly on a foundation or have any of its parts buried in earth or ashes. Furthermore, a design which does not permit free circulation of water in all of its parts is liable to produce rapid internal corrosion, for unless a current is produced by the circulation sufficiently strong to remove all bubbles of air that may attach themselves to the surfaces, rapid corrosion is almost certain to ensue. This, if neglected, may result in an explosion.

Air which is a mixture of about four parts of nitrogen to one of oxygen, together with very small quantities of other gases, dissolves to a certain extent in water. However, the oxygen, being more soluble than the nitrogen, dissolves more readily and the proportion of the gases found dissolved in the water is roughly one of oxygen to two of nitrogen, instead of in the proportions found in the air. When the dissolved air is liberated by the heat, the high percentage of oxygen causes the surfaces on which the bubbles may collect, to be rapidly corroded. This accounts for the severe corrosion of vessels containing water which is merely heated without a strong circulation being produced.

A correct boiler design will provide uniform flexibility throughout. A stiff, rigid part next to one which is flexible is a menace to safety if there is any tendency toward movement between the parts, either due to temperature changes or pressure.

Poor Workmanship

Defective workmanship is responsible for some explosions, the barbarous practice of drifting rivet holes having doubtless contributed largely in the past to such accidents. The reputable manufacturer of today, however, will not knowingly permit such work.

Failure to properly flare the tubes and nipples in water-tube boilers has frequently resulted in explosions. The safety of the joint between a tube and a plate when expanded and flared or merely expanded, is not a question of the relative strength of such connections newly made. When, for some reason connected with

the operation of a boiler, a connection of this kind becomes loose due to a movement of the parts from expansion or vibration, together with the excessive weight sometimes sustained, the tube or nipple with a flared end is decidedly more safe than one which is merely expanded. The flared nipple usually gives warning of its looseness by leakage before it pulls out.

Defective Material

Defective material is sometimes the cause of boiler explosions, and the boiler manufacturer is largely dependent upon the producer of the material for protection in this respect. Nothing but material of the best quality should be specified for all parts of a boiler which are called upon to resist the stresses produced by the pressure of steam, and every precaution should be exercised to see that such material is obtained. Cast iron should never be used in any part of a boiler called upon to resist tensile stress.

Willful Neglect

A cause of explosion which is particularly reprehensible, because of its being preventable, is due to an owner's willingness to pit his judgment against more competent or conservative advice. Often boilers are known to be in need of repairs, but the work is put off to a more convenient season. A feed pump refuses to start, and instead of fires being drawn as soon as the water reaches the lowest safe level, a chance is taken that it can be run a little longer. Pressures are sometimes carried higher than reasonable safety would permit, to avoid the expense of larger engines, or better boilers. Boilers are forced beyond a reasonable duty for the heating surface they contain. This is a feature that must be reckoned with more in the future than it has been in the past.

Neglect or Careless Operation

Boiler explosions are also the result of neglect or carelessness in operation. Scale and deposit are often allowed to collect in quantities that are dangerous; connections to water columns are allowed to become stopped; oil is permitted to enter the boiler with the feed water; repairs to settings which may affect the safety of the boiler are neglected; safety valves are not regularly tested to ascertain if they are in operating condition; or occasionally an owner who discovers the safety valve leaking, with an eye blind to every consideration except the prevention of loss of steam, places a stop valve on the connection to the safety valve or plugs the outlet. A steam gage may register incorrectly and the engineer screws down on the safety valve in an endeavor to make the gage show the correct pressure.

Again, the steam pressure may not be sufficient to produce the results desired and the safety valve is deliberately made inoperative to overcome the difficulty. All of these conditions have been the cause of boiler explosions in the past and they probably will continue to contribute their share in the future until the steam user is more thoroughly educated in the matter of the risk he runs by such carelessness.

Tube Failures

Tube failures, which are chiefly confined to the water-tube type of boiler, are a source of grave concern to the boiler-insurance interest because it is difficult to guard against the usual failure of this kind by inspection. A defective weld usually does not show on the surface of the tube, and even where the surface indications would lead to suspicion, a large percentage of the tubes in water-tube boilers are beyond the reach or vision of the inspector. The thorough inspection of tubes before they are placed in the boiler, while very unsatisfactory, even taken in connection with the mill test, is about the only protection possible against accidents due to this cause.

The seamless tube will prevent accidents due to defective welding, but tubes made by this process are not always of uniform thickness, and with the cold-drawn product there are apparently internal strains produced by the process of manufacture which sometimes cause the tubes to break when merely heated. If cold-drawn tubes are used for boiler purposes, the annealed stock should be obtained. Hot-drawn seamless tubes are now meeting with considerable favor among engineers for boiler purposes.

A considerable percentage of tube failures occur without the slightest evidence as to their cause. A welded tube frequently breaks through the solid metal away from the weld, without being corroded or weakened in any way that may be detected by the eye, and without evidences of overheating. There must be some reason for such failures.

It is a fact that while pressures and rates of driving have been remarkably increased during the past 15 or 20 years, no increase in the thickness or strength of tubes has occurred. That the thicker tube is safer seems to have been demonstrated by a number of cases where heavy tubes have been used in place of those of standard gage, and tube troubles have ceased. Of course, it can be contended that the theoretical factor of safety is higher on tubes even of standard thickness than on almost any other portion of the boiler. However, under operating conditions accompanying high rates of driving, is it not possible that there are decided fluctuations in the temperature of the material in the tubes? The rapid formation of steam bubbles removes for a certain interval of time the water protection from the inner surface of a tube, and the thinner the material, the higher will its temperature rise during a given time in which it is not protected. It is conceivable that the structure of the metal in a thin tube may be affected in time by this constant change in temperature until it gives out, while the thicker tube might not be affected to the same extent by this means. This idea is only advanced as a possible explanation for some of the tube accidents which seem to defy definite causes being assigned for them.

The thicker material in the case of welded tubes will make it more certain that the required strength is obtained in the weld; also, surface imperfections in the material would not affect the strength to the same degree in the thick tube as it would in the lighter one.

The importance of the question of tube failures to the operator of boilers as well as to the insurance interest can be appreciated when it is realized that the toll of loss of life and limb exacted by such failures probably exceeds other classes of boiler accidents when the relative number of fire-tube and water-tube boilers in use is considered.

Other Causes

Corrosion has been the cause of many serious explosions, but with boilers built accessible for inspection, explosions from this cause may be reduced to a minimum where the boilers are under the care of a competent inspection service.

A source of explosions, external to the boiler itself, but which has produced very serious disasters, is the improper arrangement of steam piping. It is very dangerous indeed to attempt to connect a boiler to a steam line where the piping is arranged so that water pockets may be formed. A water-hammer is likely to result in such cases which may break the pipe connections, and this in turn may produce an explosion of the boiler itself.

Very disastrous explosions have been due to hidden cracks or so called lap-seam cracks. The cause of these defects is either the form of seam, poor material, improper shape of the joined ends of the sheet, or the abuse of the material in the process of manufacture; possibly it may be a combination of some of these causes. That the form of seam alone is not the only factor is well demonstrated by the fact that all lap seams do not fail in this manner and also that some seams of the butt-joint type have thus failed.

It is readily recognized that with every possible precaution, boiler explosions cannot be entirely eliminated, but their number may be lessened materially. A proper inquiry into all accidents of this kind by government officials qualified and clothed with ample authority would tend to reduce the number of explosions.

Large Southern Central Station

By D. J. O'Brien*

A combination steam-turbine and reciprocating-engine plant supplying commercial light and power to the city of Birmingham, Ala., also the street-railway system.

The turbines are run condensing, but the exhaust from the engines is used for heating a large section of the city.

*Chief Engineer of the Birmingham Ry. Light & Power Co.

One of the largest steam power plants in the South is that of the Birmingham Railway, Light & Power Co., at Birmingham, Ala. Besides supplying the street-railway system and the commercial light and power for the city, it also furnishes exhaust steam for heating to the business districts. The turbines in the plant, however, are run condensing, but as an abundant supply of condensing water is not available cooling towers have been employed.

Certain features of this plant were described in the Aug. 16 and Oct. 4, 1910, issues of POWER. Although these details will be largely omitted in the present description, a general outline of the installation will be included in order to acquaint the reader with the character of the plant.

The station contains 31 boilers, totaling 17,200 boiler horsepower, and generating units, both engine and turbine-driven, aggregating 30,000 hp. The services supplied consist of a 125-250-volt Edison three-wire system; a 2300-volt three-phase system supplying the arc-lighting system; a 13,200-volt transmission system, and a 600-volt direct-current railway system.

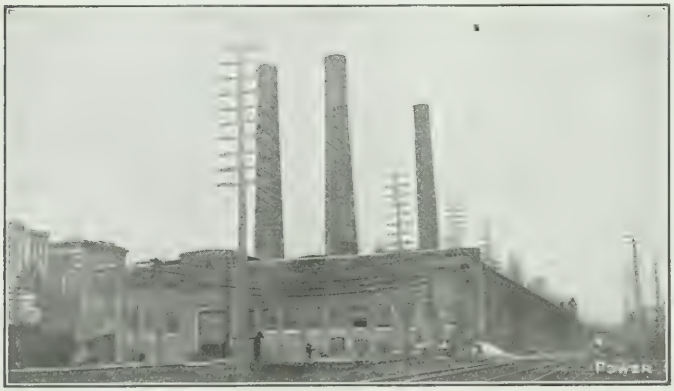


FIG. 1. EXTERIOR VIEW OF STATION

BOILERS

The boiler installation consists of twenty-four 600-hp. and seven 400-hp. Babcock & Wilcox boilers, each equipped with chain-grate stokers and fitted with wrought-iron pipe water-backs at the bridge-walls. A washed mixture of nut, pea and slack coal averaging about 13,000 B.t.u. per pound is used. This is brought to the plant in cars and dumped into concrete bins holding about six tons each. From these it is discharged to a belt conveyor about 440 ft. long which, in turn, discharges into a concrete pit holding about 20 tons. From here the coal is elevated in a two-ton skip bucket to a hopper located above the level of the coal bunkers and, after passing through a crusher, falls upon a distributing belt and is distributed to the coal bunkers. These discharge through chutes to the stokers.

The coal which drops through the chain-grate stokers is drawn from the ashpits with long-handled shovels and is dumped into the ash buckets. These are hoisted and emptied into a car which is run out over the coal-receiving pit. This method allows the coal droppings to become thoroughly mixed with all the coal burned, and prevents clinkers which would be formed if the droppings were shoveled directly into the stoker hopper of each boiler. The heat units in these droppings are estimated to average about 7000 B.t.u. per pound.

The coal is purchased on a B.t.u. basis, the analyses of the samples for each month being averaged and the price determined thereby. Both premiums and penalties are provided and these are based not only upon the heat value shown by the average analysis, but also upon the percentage of ash and sulphur.

The ashes are handled by telpher-operated buckets and discharge into hand cars by which they are removed from the boiler room.

In connection with the operation of the boiler room, it may be mentioned that the external surfaces of all the tubes are cleaned daily, and it is the duty of the men who blow the surfaces of these tubes to also stop all air leaks in the settings and furnaces. An air-driven tube cleaner is now used, and this has been found to result in longer life of the arches of the dutch ovens, for when the tubes were cleaned with a water-driven cleaner a large amount of the leakage dripped on top of the arches, and consequently shortened their lives. It is the custom to clean each of the boilers in service every 35 days.

HEATER AND PUMPS

Feed water is furnished by two separate 6-in. city mains leading to an open surge tank located on the roof of the boiler room. From here it flows by gravity to two 10,000-hp. Cochrane feed-water heaters, thence to the feed pumps. The discharge from the water-backs at the bridge-walls, which is under the city pressure of 90 lb. per square inch, is also connected into this system. Furthermore, there is a connection between the city mains and the boiler-feed pumps for emergency use, and additional protection against shutdown is afforded by a 6-in. two-stage centrifugal pump which can supply the main feed-pump suction with water from the station reservoir in case of trouble with the city mains.

ENGINE AND GENERATORS

The generating equipment consists of six Corliss engine-driven units and three turbo-alternators, all receiving steam at 175 lb. pressure, and 100 deg. superheat. The engines were originally designed double, but have now been made cross compound.

The railway system is supplied by one 1600-kw. and two 850-kw. 600-volt units, and the Edison three-wire system by one 400-kw., 125-250-volt generator, which also serves as an auxiliary for the exciter system. The 2300-volt system is composed of two 1500-kw. engine-driven units, two 3000-kw. Curtis turbines, and one 6250-kw. Allis-Chalmers horizontal turbine. These exhaust into a LeBlanc condenser.

Three 1000-kw. Westinghouse rotary converters also form part of the railway system in parallel with the railway generators, and the Edison three-wire system includes three 750-kw. and two 500-kw., 125-250-volt rotary converters. The connections of two of the 750-kw. rotary converters are so arranged that they can

be run in series and paralleled on the railway system for emergency operation.

Excitation is furnished by motor-generator sets with an engine-driven exciter in reserve.

The arc-lighting system is supplied by six 100-light, seven 50-light and one 35-light constant-current oil-cooled transformers which furnish 7½-ampere series arc lamps with current from the 2300-volt system.

The 13,200-volt transmission system which furnishes power to the towns of Bessemer, East Lake, Ensley, Brighton, etc., is supplied from the 2300-volt system through three 750-kw. step-up transformers.

Cooling Towers

The cooling towers which have been installed to handle the condensing water are of the Worthington design, 30 ft. in diameter and 80 ft. high. They are built over the suction reservoir and are equipped for forced or natural draft, or a combination of both, and are connected to the condenser by 36-in. cast-iron mains. Motor-driven fans are employed.

Exhaust Steam Heating

The station is located about 1500 ft. from the business center of the city and in all there are about 11,500 ft. of heating mains ranging in size from 4 to 16 in. In the construction of this system of underground piping, thorough provision has been made for insulation, expansion, anchorage and durability. The wrought-iron pipe is first wrapped with asbestos paper, which is held in place by copper wire. Between the pipe and the wooden insulating casing there is a 1½-in. air space, the pipe being centered and supported on roller guides which permit movement due to expansion and contraction.

The chief insulation is secured by a wooden casing 5 in. in thickness. It is made from kiln-dried tongue-and-grooved white pine staves tightly bound together with a galvanized-iron wire, which is bound under a pressure sufficient to embed it into the wood. The casing is then covered with a coating of asphaltum and sawdust and the inside is lined with bright tin plate.

Great care was exercised when the mains were installed to protect them from seepage and provide proper drainage. For this purpose 3-ply tar paper was laid on top of the casing to a point below its center line and porous tile is placed below the mains; these being connected to the sewers at convenient points.

A device known as a variator is used for taking care of the expansion and contraction of the mains. This consists of a form securely anchored in a brick box, which holds the outer edge of a large corrugated copper disk, the inner edge of which is connected to the free end of the pipe. The expansion devices are placed about every 100 ft. apart,

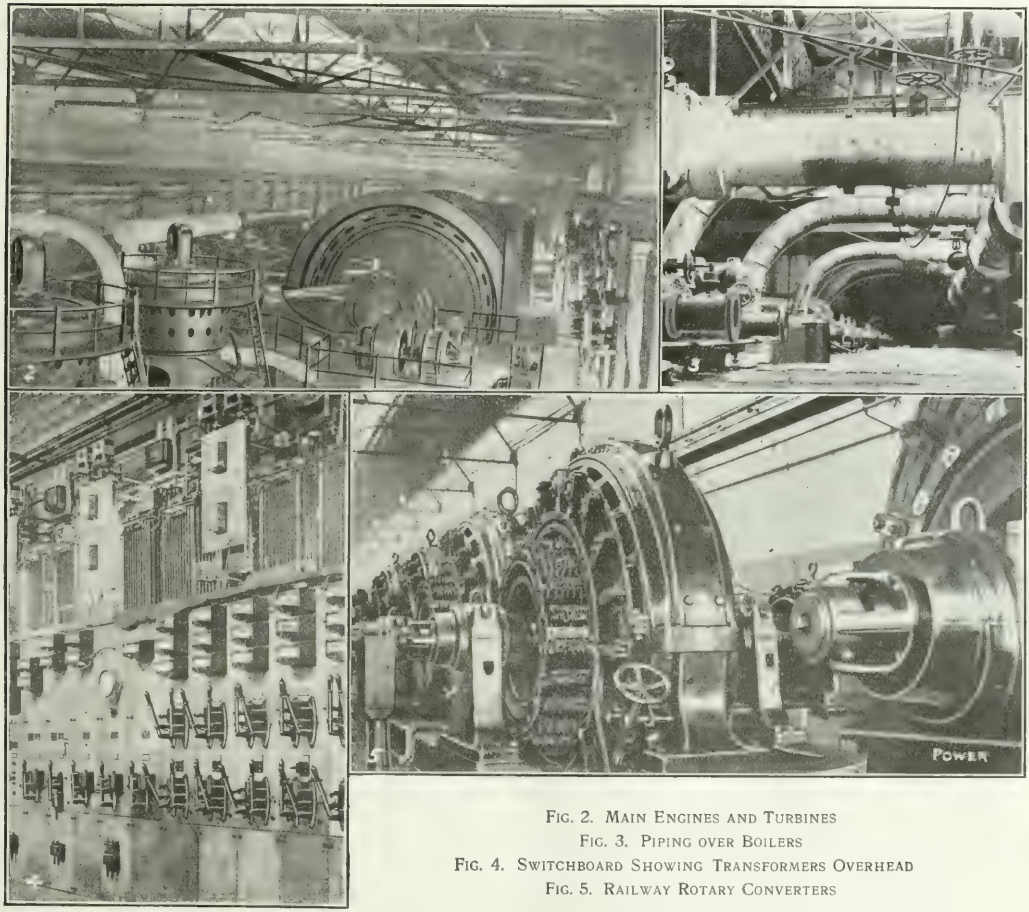


Fig. 2. Main Engines and Turbines
Fig. 3. Piping over Boilers
Fig. 4. Switchboard Showing Transformers Overhead
Fig. 5. Railway Rotary Converters

with anchors midway between. All the brick boxes inclosing the variators and anchors are filled with pine shavings to prevent radiation.

Consumers' service pipes branch from the top of the main line, thus insuring the delivery of dry steam to the consumer. Four-inch wooden casings are used for insulating the service pipes. Gate valves are placed in manholes at street intersections, so that small sections of the system may be shut off to make connections or repairs.

All the pipes are carefully graded to low points on the system where automatic steam traps are placed in manholes for the removal of condensation.

The consumers comprise practically all the small and large office buildings, business blocks, hotels, and public buildings, and all are served on a meter basis.

Explosion of Water Tube Boiler

By A. L. Howard

The accompanying photographs show the destruction following the explosion of a water-tube boiler at the mill of the Bond Lumber Co., of Bond, Miss., on Feb. 19. Besides the damage to property, estimated at about $60,000, three men were killed and two others seriously injured.

The boiler which exploded was of the Woods type and was rated at about 200 hp. It was built in 1894 for the Eddy Co., of Saginaw, Mich., by which firm it was used until 1902. It was out of service for the next three years, remaining in a damp and often flooded boiler room, and was then sold to the J. E. North Lumber Co. (now the Bond Lumber Co.) who operated it up to the time of the explosion.

On Sunday, Feb. 18, the day before the explosion, the boiler was washed out and was fired up about 11 p.m.; the explosion occurred at 2:05 a.m., Monday morning. Several versions are given as to the contributing cause of the explosion, one of the attendants stating that the water was low and upon turning on the injector the explosion took place. It is probable, however, that definite information will soon be available as to the actual cause, as a thorough investigation is now being made by the authorities and the insurance company which held insurance on the boiler.

The boiler plant consisted of five return-tubular and four water-tube boilers. The front tube header of the exploded boiler was thrown about 1500 ft. from the plant and part of the steam drum was hurled onto the log deck of the sawmill. The rear tube header was blown through the sawmill and landed under the filing room.

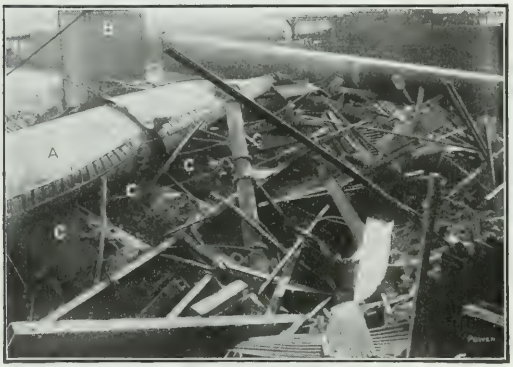


FIG. 1. SHOWING STACK A OF EXPLODED BOILER LYING ACROSS THE RETURN-TUBULAR BOILERS C; B IS THE BASE OF THE STACK FOR THE LATTER BOILERS

FIG. 2. DEMOLISHED BOILER ROOM; D SHOWS WHERE STEAM DRUM WENT THROUGH SAWMILL; AND E THE STACK OF THE EXPLODED BOILER

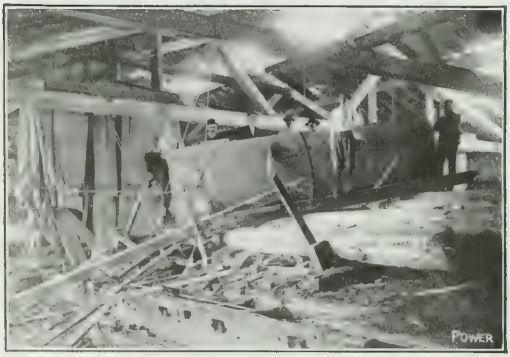


FIG. 3. STEAM DRUM OF EXPLODED BOILER ON LOG DECK OF SAWMILL

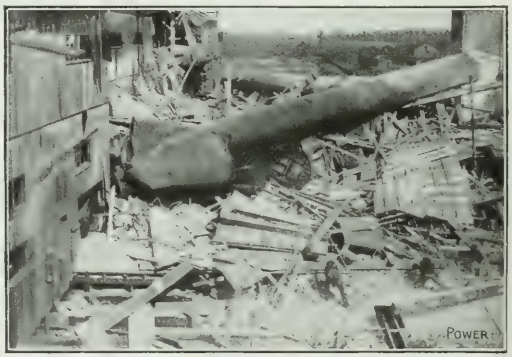


FIG. 4. END VIEW OF BOILER ROOM

William States Lee

Few men have contributed as much or as efficient personal endeavor to the industrial development of any section of the South as William States Lee, chief engineer of the Southern Power Co. Mr. Lee was born in 1872 in Lancaster, S. C., and after the usual primary education he received technical education at the South Carolina Military Academy, from which he was graduated in 1894. After graduation he taught for a time, but soon took up engineering work and rose rapidly from transit man to resident engineer of the Pickens Railway Co.; subsequently he became resident engineer of the Anderson Water, Light & Power Co. When with the latter company he had charge of the construction of the Portman Shoals hydro-electric plant on the Seneca River, in which was installed the first 10,000-volt generator put in service in America. After putting this plant into operation, Mr. Lee spent about a year on construction work in connection with the United States Government coast-defense plans for Charleston Harbor.

In October, 1898, he became resident engineer of the Columbus Power Co., which company had just then let the contract for a dam on the Chattahoochee River at Columbus, Ga. This dam was completed in the autumn of 1900 and in December of that year part of it was carried away by a flood. The reconstruction of the dam, together with the building of transmission lines, substations, etc., was put under Mr. Lee's direct supervision and he was made chief engineer. He modified the design and raised the height of the dam, completing it in the spring of 1902. It is to be noted that this river is remarkable for its quickly rising floods, which often exceed fifty times the normal flow. This was the first large dam built in the South, and the experience gained in fighting a river with such quickly rising floods may account for much of Mr. Lee's success in later developments where similar conditions were encountered. During his connection with this company Mr. Lee also became familiar with cotton-mill construction, an experience which has served him well in his present connection.

After reconstructing the dam at Columbus and completing the electrical installation, he was appointed chief engineer of the Catawba Power Co. This company was building a dam at the India Hook shoals of the Catawba River, near Rock Hill, S. C., and three contractors had failed in the undertaking on account of the great difficulty involved in dealing with the floods which rise in this river. The dam was completed in the spring of 1904, together with transmission lines to Rock Hill and Charlotte (N. C.). The capacity of this plant was 10,000 hp., and the rapid sale of the entire output led to the formation by the same interests of a much larger company under the name of the Southern Power Co., which took over the Catawba Power Co. and purchased large water-power rights on the Catawba and Broad Rivers in the summer of 1905. Mr. Lee was made chief engineer and in addition was given an executive office, second vice-president, with headquarters at Charlotte.

Before the organization of this larger company, hydro-electric development in the South had been mostly local in scope, having for an object the supply of power to a few cotton mills in the immediate neighborhood of the power plant or at the end of a comparatively short transmission line. It remained for Mr. Lee to produce a network system extending over hundreds of square miles and rivaling in the amount of power transmitted

William States Lee

any hydro-electric system in the world. Since the summer of 1905 there have been built under his direction two 24,000-kw. and one 18,000-kw. hydro-electric developments; 500 miles of 50,000-volt circuits; 800 miles of 100,000-volt circuits and about 70 substations supplying power and lighting to more than 150 cotton mills and 45 towns. The pioneer work involved in this project included the erection of a 100,000-volt transmission and distribution system reaching 200 miles in one direction and over 100 miles in another direction, tied in to a 50,000-volt distributing system and operated with the same degree of safety as a low-tension system.

Not content with supplying power to the mills of the Piedmont region, Mr. Lee has for several years been studying the railroad problem, and has so far interested the financiers of the Southern Power Co. that for the last year he has been actively engaged in the construction of a high-speed freight and passenger electric railway, 150 miles long, which for the present will connect with the Seaboard Ry. at Charlotte and Greenwood. He is also making a study of the problem of extracting nitrogen from the atmosphere by means of the electric arc. A plant for this work has been in course of contruction at Great Falls for more than a year, and it will probably be in operation by the time this sketch appears in print.

Mr. Lee possesses to a remarkable degree the unusual combination of keen business sense and engineering ability, which enables him not only to design, construct and operate his plants, but also to develop them to their fullest commercial efficiency and put them on a firm business basis. His ability to analyze quickly the most difficult problems and his knack of inspiring confidence in all with whom he comes in contact are striking characteristics.

He has always taken an active part in industrial and other affairs which pertain to the welfare of this country. He has, for instance, been warmly interested in the preservation of the natural resources of the country, especially of the forests, and has appeared before the congressional committee on conservation of forests at various times.

Although Mr. Lee has always been and is still a very busy man, he always has time to discuss matters with his men, or with his customers, or to help along any project tending to the advancement of the interests of the community in which he lives.

Mr. Lee does not impress the casual observer as being aggressive, but his excellent judgment, quiet but indefatigable perseverance and great personal magnetism produce results that demonstrative aggressiveness would not. His successful work in connection with the Southern Power Co. and its allied interests has attracted the attention of the electrical and commercial world by reason of the comprehensive range of its operations, and has caused financial powers to show more confidence than ever in the future of the South.

Mr. Lee is a member of the American Institute of Electrical Engineers, the American Society of Civil Engineers and the American Society of Mechanical Engineers; president of the Engineering Association of the South, and of the Greater Charlotte Club and the Commercial Club of Charlotte.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

An East Tennessee Hydro-electric Development

By F. R. Weller*

There has recently been completed and put in operation in Carter County, Tenn., a hydro-electric power plant which has the distinction of being the first important plant of this character completed in the state. The power house is located on the Watauga River, eight miles above Elizabethton. This river rises in the mountains of western North Carolina, and is fed by many large springs, which tends to yield an uniform minimum flow. The total drainage area above the site of the dam is 406 square miles.

The dam and power house are constructed at a point where the river breaks through the last of the mountain gorges previous to flowing through a wide cultivated valley to its junction with the Holston River. At this point the rocky cliffs are very precipitous and afford excellent anchorages for the dam.

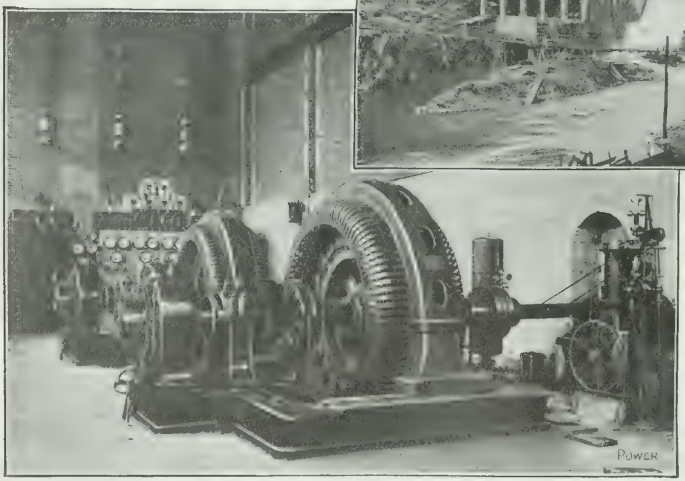


Fig. 1. A Corner of the Watauga Generator Room

The dam and abutments are 270 ft. long and the spillway crest of the dam is 55 ft. above low water. The thickness of the dam at the base is 58 ft. 6 in. It is of the gravity type built of cyclopean concrete in proportions of 1 to 2½ to 5 on the face and 1 to 3 to 6 in the core of the dam. The upstream face of the dam is vertical and the downstream face has an ogee profile.

The north end of the dam is built up in an abutment wall in which are set the head racks and gates for controlling the water to the turbines. The power house is on the downstream side of this part of the dam, as shown in Fig. 2. Three 10-ft. steel penstocks have been built thus far in the abutment wall. Each penstock carries the water to a pair of 33-in. Morgan Smith wheels mounted on a horizontal shaft. At the present time only two units have been installed, but full provision has been made for another unit of the same size later on.

The wheels are inclosed in steel cases and are located between the power-house wall and the face of the abutment wall. Steel draft tubes carry the discharge water into the tailrace under the power house. Considerable expense was involved in the construction of this tailrace, which required the excavation of over 15,000 yd. of solid rock in order to keep the tail water flowing from the wheels separated from the water flowing over the crest of the dam for a sufficient distance below the dam to maintain a uniform head during normal periods of flow.

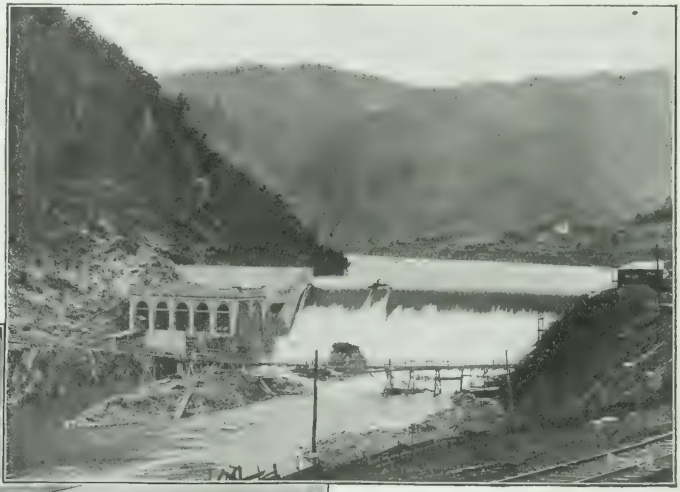


Fig. 2. Watauga Power House

Power House and Equipment

The power-house superstructure is supported by means of 4-ft. piers carrying full centered concrete arches with 14-ft. spans and crowns 3 ft. thick. The superstructure is built of reinforced concrete with brick spandrel walls. The windows, frame and sashes are of steel—in fact, the whole power house is absolutely fireproof with the exception of the wooden roof sheathing.

The turbine gates are controlled by hydraulic governors, each belted to the turbine shaft, as shown in Fig. 1. Each turbine shaft extends through the wall of the power house and is direct-connected to the shaft of a 1000-kw. Westinghouse alternator delivering three-phase currents at 60 cycles. Each generator is separately excited at 125 volts

*Consulting engineer in charge of the design and construction of the plant.

by means of a direct-connected 50-kw. shunt-wound exciter. The switchboard controlling the output is very compact; it stands in one corner of the building, as shown in Fig. 1.

The cables are laid in conduits in the floor and are insulated with varnished cambric and lead-encased. In the north end of the building, back of the switchboard, are installed three single-phase oil-insulated air-cooled transformers, of 800 kilovolt-amperes each, which raise the voltage from 2200 to 44,000 volts for the transmission line. In the station are provided the necessary high-tension oil-break switches, disconnecting switches and choke coils and immediately outside of the power house are installed 44,000-volt electrolytic lightning arresters. All of the auxiliary electrical equipment is of Westinghouse make.

Transmission Line

The transmission line extends from the power house to Bristol, Tenn., a distance of 20 miles, and Elizabethton, about 7 miles distant. At a point about five miles from the power house a line branches off and runs to Elizabethton. At this junction is installed a switching tower with the necessary disconnecting switches for cutting out either line from the main trunk line.

The transmission line is of No. 3 stranded aluminum, with 175-ft. spans most of the way. On spans exceeding 200 ft. a steel-core wire is used in conjunction with the aluminum wire in order to relieve the tensile stress on the conductors. The line is mounted on 50,000-volt Thomas insulators with Lee wrought-iron pins. The wires are strung 5 ft. apart, center to center, with delta spacing. They are supported on second growth chestnut poles, except at the entrance into Elizabethton, where 55-ft. steel towers are used.

At Bristol there is a substation containing three step-down transformers, each of 800 kilovolt-amperes capacity, reducing the voltage from 44,000 to 2200 for delivery to the Bristol Gas & Electric Co.; all electric power transmitted to Bristol is distributed by this company for the usual lighting and power purposes. At Elizabethton, the power is delivered through step-down transformers to the Watauga Power Co.'s own central station. The lines at the entrance to each substation are equipped with electrolytic lightning arresters.

Full consideration was given to the relative merits of copper and aluminum for transmission-line purposes. In this section the rainfall is very heavy and severe sleet storms occur during the winter months. It had been found by previous experience that there is less trouble from the formation of sleet on aluminum than on copper conductors, and this has been confirmed in the operation of the plant during the past winter months, when practically no difficulties developed from this cause. Aluminum conductors being 50 per cent. lighter than copper of the same conductivity, the pole spacing can be increased and the cost of the poles and setting them thereby reduced.

The construction of the dam and power house was carried out under great difficulties, due to floods, freshets and severe weather, by R. L. Weide, resident engineer during this period, and Mr. Weide is entitled to much credit for the expedition and thoroughness with which this work, as well as the erection of the transmission lines through wild, rough country, was accomplished.

Armature and Coil Testing Outfits

The advantage of using alternating current for testing purposes is well exemplified by the facility with which armatures and individual coils may be tested for breaks and short-circuits by means of the testing sets illustrated herewith. One of these, Fig. 1, is for testing individual coils and the other is for testing a complete armature winding.

The apparatus shown in Fig. 1 consists of an E-shaped electromagnet with a detachable "keeper." An exciting coil surrounds the middle leg of the E. On the yoke of the E, between the middle leg and each outside leg, are wound two small coils so connected that the potentials induced in them by the flux set up by the exciting coil oppose each other and are exactly equal under normal conditions; consequently, no current flows under such conditions. The magnet or armature coil to be tested is placed over one of the outer legs of the E and the

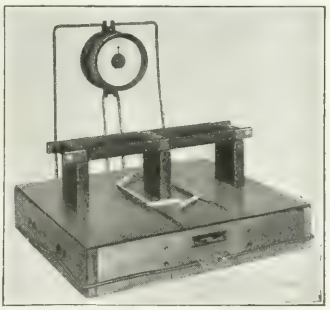


Fig. 1. Coil-testing Outfit

armature bar is omitted. If the tested coil is without fault, it has no effect on the flux distribution. If, however, a leak or short-circuit exists, a current is induced in the short-circuited part of the tested coil which so alters the distribution of the flux that more passes through one of the detecting coils than through the other, inducing higher voltage in one than in the other and thereby causing a current to flow through them. This current is indicated by means of a central-zero millivoltmeter or by means of a special telephone receiver.

To locate a short-circuit in a coil by burning it out, the coil is placed on the middle leg of the E, the detachable armature bar put in place as shown in Fig. 1, and the exciting coil connected to an appropriate source of current for a short time.

The device for testing complete armatures, illustrated in Fig. 2, consists of a bipolar electromagnet with a laminated iron core in which an alternating magnetic flux is set up by connecting the terminals of the exciting coil to a source of alternating current. When the pole faces of this magnet, which are shaped to fit the curve of an armature core, are applied to either a direct-current or an alternating-current armature carrying a winding connected to a commutator, an alternating flux passes through the armature core and if the armature winding is in normal condition, the electromotive forces generated counterbalance each other and no current passes through the winding.

Passing a piece of metal around the commutator short-circuits in succession each of the coils, and if there is no fault

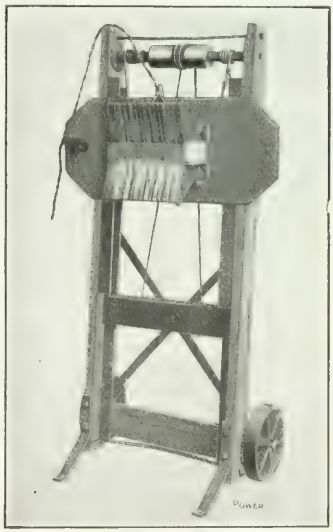


Fig. 2. Armature-testing Magnet

in the winding a decided spark occurs as the metal leaves each bar. Absence of spark between two bars indicates either a short-circuit or an open-circuit, and it may indicate a reversed coil in the winding. Either a short-circuit or reversed coil will cause a local current in the coil which will generate a flux in the teeth between which the coil lies; this local flux can be detected by running

over the surface of the armature a piece of sheet iron held lightly, bridging from one tooth to the next successively. A local flux caused by a short-circuit or reversed connection will attract the piece of iron when it bridges across the slot containing the defective coil. If no such local flux is detected, the fault disclosed by the sparking test is due to an open circuit.

The magnet is mounted either on a stand provided with wheels, as shown here, or on a stationary stand. Two sizes are made, one for armatures under 12 in. in diameter and one for armatures 12 in. or more in diameter.

These testing sets were originally built by the Westinghouse Electric & Manufacturing Co. for use in its own shops only, but they proved so satisfactory that the company recently decided to build them for general sale.

Promiscuous Paralleling

By George W. Malcolm

The Georgia Railway & Electric Co., of Atlanta, operates both water-power and steam generating plants, and in the steam station there is also a 3000-hp. Snow gas engine which is operated on illuminating gas only while the peak load is on. During the small hours of the night and part of the day, water power alone is used, except on cloudy days when the lighting load is heavier than usual. When the load gets beyond the ability of the hydraulic station, a 1000-kw. Corliss-engine unit is put in parallel with the high-tension line at the Davis Street station in Atlanta. Later in the afternoon a 2000-kw. steam-turbine unit is put on the line, and about 5:30 or 6 o'clock, according to the season, the gas-engine unit is added.

These four different types of prime mover drive three-phase 60-cycle alternating-current generators in parallel (through step-up and stepdown transformers between the water plant and the city station) with the utmost harmony. There is no surging, and cross-currents are practically eliminated by giving a little attention to the adjustment of the field excitation occasionally. The writer visited the Davis Street station one afternoon recently and witnessed the addition to the system first of the turbine unit and later of the gas-engine unit, and was greatly impressed by both the smoothness with which these units "went in" and the placidity with which they divided up the load after going on the line.

The current from the water-power plants comes to the city limits at 50,000 volts and is there stepped down by transformers to 11,000 volts, at which pressure it is transmitted to the Davis Street station. This station is the distribution center of the system.

Ilgner Drive for Rolling Mills

In the course of a paper relating to electric driving of rolling mills, read at a recent meeting of the (British) Institution of Electrical Engineers, C. Antony Ablett referred to the necessity for a mill motor, when used in conjunction with a flywheel, to fall in speed when the power demand is large, so as to enable the flywheel to give up some of its stored energy, which causes a diminution in the tonnage which the mill can roll. This reduction of tonnage is more marked where the mill is engine-driven than where it is motor-driven.

To overcome this difficulty, Mr. Ablett says that several steel works have adopted the Ilgner system for driving large three-high mills—that is, the same type of electrical plant is used which is generally employed for driving reversing rolling mills. In this system the flywheel is not attached to the mill but to a motor-generator set which supplies current to the mill motor. The mill motor runs at a constant speed whatever power it is required to give; consequently, there is no reduction in tonnage owing to reduction in speed in the mill. The motor-generator set, instead of the rolling mill motor, varies in speed so that the flywheel can give up its stored energy when the power demand is great and absorb energy when the demand is small in order to reduce to a reasonable value the variation in power taken from the supply system.

It is claimed that by using the Ilgner system the possible output from the mill can be increased beyond that which may be obtained if the mill motor were driven directly at constant speed. The capital cost of the electrical plant for this system of driving is higher than that of a plain motor and flywheel, but it enables a much larger output to be obtained and therefore cheapens the cost of production by reducing the capital charges per ton rolled.

Some of the salient points brought out in the paper are the following:

The stored energy of the flywheel varies as the square of the speed at which it is running, so that if a flywheel were used in conjunction with a three-phase induction motor running at light load it would give up only 4 per cent. of its stored energy as the power increased from light load to full load on the motor.

The value of the time constant for a motor and flywheel does not usually exceed about 33 seconds. The value of the time constant to be selected naturally depends on the type of mill. In a sheet mill where the duration of the passes is very short the time constant need not be so big as in the case of a bar mill where the finishing passes may take considerable time. The greatest time constants are found in the case of motor and flywheel for the motor-generator set of an Ilgner system applied to a reversing rolling mill.

The difficulty with the intermittent-slip regulator is that it is comparatively slow in coming into operation on account of the inertia of the various moving parts. Such slip regulators often take from 1 to 2 seconds to come into operation, and as the increase in power demanded from a rolling-mill motor when the rolls bite the bar is practically instantaneous, the power will rise to its maximum value before the intermittent-slip regulator can come into operation. Therefore, instead of reducing the power to the mean value, as would appear to be the action of the automatic-slip regulator from academic considerations, it actually is the means of producing very bad peaks indeed.

Care should be taken that the hourly output of the mill is kept as steady as possible, for if the mill were worked rapidly for an hour or two and then there was a long wait for billets to heat in the furnace, or for some other cause, the rapid rolling would be found to affect the cost of power very adversely.

The ideal drive is a constant-speed motor for the roughing mill and a separate variable-speed motor for the finishing mill; when this is done the roughing and finishing mills are usually worked in tandem. Where the supply available is direct current, this arrangement presents no difficulty, but where three-phase current must be used, the means of providing a variable-speed drive for the finishing mill needs careful consideration. The simplest arrangement would be to provide an ordinary three-phase motor and to reduce its speed when required by inserting resistance in the rotor circuit.

Generally speaking, where there is a choice between direct and three-phase currents for driving a mill for which variable speed is desirable, and there is little or no difference in the cost of electricity, the adoption of direct current will be found the most economical.

In many mills the power consumed by the friction of the mill itself is about ⅓ or ¼ of the normal rated output of the motor which is installed to drive the mill, so that nearly 50 per cent. of the electricity used per ton rolled is wasted in friction.

In certain mills, particularly in brass and copper sheet mills, long trains of gearing are usually put in for transmitting the power of the motor to the rolls and are so arranged that the power for the more distant mills is transmitted through perhaps ten different pairs of gearwheels; a more wasteful way of applying power could hardly be imagined.

The electrical drive often allows cheap power to be used when it could not be transmitted or applied in any other way.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

A Dependable Small Producer Plant

By R. C. Turner

At the Fulton County almshouse, 10 miles out from Atlanta and isolated from all railroads and traction facilities, is to be found one of the most interesting very small power plants in the South. When the question of furnishing the buildings with water and electricity was considered by the county commissioners, three different proposals were entertained: first, one for a complete steam plant, with high-speed engines; second, one to build a transmission line five miles in length and take current from the local hydro-electric power company, installing at the almshouse three-phase transformers to step the current down to 220 volts for lights and power; third, one for a complete local gas power plant.

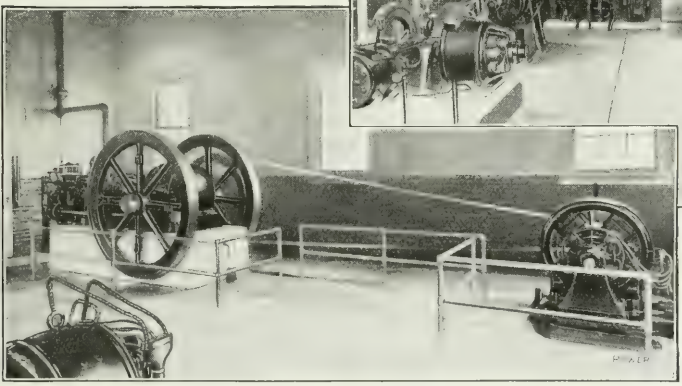


Fig. 1. The Main Generating Unit

On account of the long haul of coal from the railroad, six miles away, over a rough and hilly country, the cost of operating a steam plant was considered too high, and in consideration of the uncertainty of continuous service and the high cost of the pole line and transformers, the straight electrical plan was discarded. The proposal to install a gas engine and bituminous gas producer was accepted.

The contractors were asked to install the simplest plant possible, keeping in mind the location of the plant and the service to be rendered. Following out this idea, it was decided to install a bituminous gas-producer outfit, a simple single-acting gas engine belted to a direct-current generator, and an air compressor driven by a small gasoline engine for providing air to blow up the producer and start the engine and by a motor supplied with current from the dynamo belted to the main engine, after that is running. These auxiliaries are shown in Fig. 3.

The gas producer is the special feature of the equipment. It is an Akerlund down-draft apparatus, the draft for which is maintained by a motor-driven exhaust fan. From the generator the gas passes through a cooler and a coke-filled wet scrubber; from there, through the exhauster to an expansion tank and thence to the engine at a pressure of about 4 in. of water. A detailed consideration of the producer system is worth while. Fig. 6 gives a sectional view of the complete system. The generator is fitted with a water pan *H* in the top from which water and steam pass to the main vaporizer *V* around the combustion zone. The water level in the pan *H* is maintained by an overflow *E* which delivers to the main vaporizer *V;* a pipe, not shown, connects the *top* of the pan *H* also with the vaporizer and transfers any vapor that may be formed in the pan. An overflow standpipe *F* serves to seal the vaporizer and also to limit the upper water level therein.

Water is supplied to the pan *H* through the small pipe shown at the right-hand side of the generator top and the supply is regulated by hand; the rate of delivery from the pan to the vaporizer is observed at the overflow outlet *E*.

Air for the generator is taken in at *A* and passes through the vaporizer *V* to the uptake pipe *B*, which delivers the air, with steam, to the top of the generator chamber. The gas-making process is the same as in any down-draft single-zone generator. From the generator, the gas passes through the outlet *D* to the cooler, which consists of two vertical pipes connected at the top ends by a water-sealed baffle chamber or trap *G* and containing about half a dozen water sprays in each leg. From the second leg of the cooler, the gas passes through the wet scrubber, exhauster *J*, dry purifier and delivery pipe *K* to the engine.

Immediately above the tee connecting the dry purifier with the delivery pipe *K* is an automatic bypass valve *L* which is set to open when the pressure exceeds the normal, thereby allowing some of the gas to pass through the pipes *M* and *N* back to the scrubber, the three-way valve at the junction of the pipes *M*

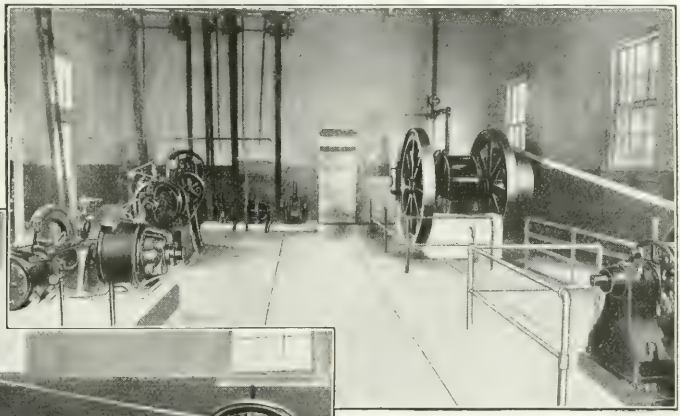


Fig. 2. Motor-driven Pumps and Main Engine

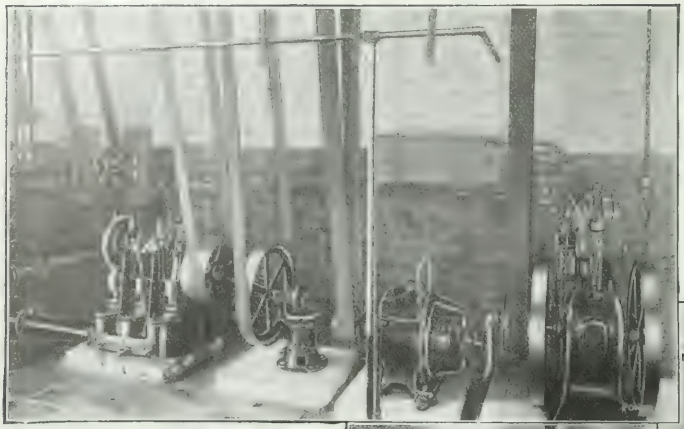
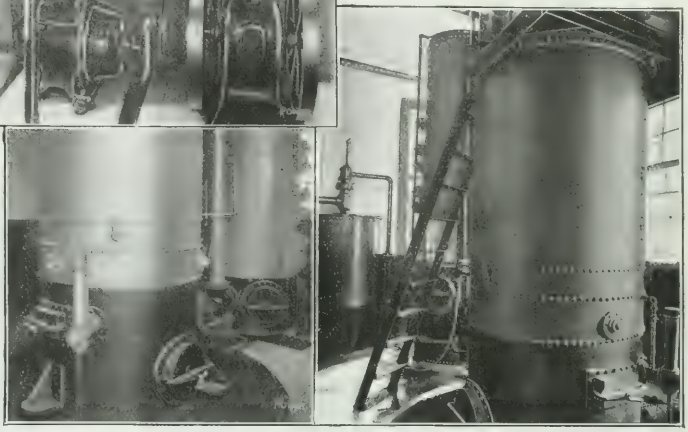


FIG. 3. POWER-PLANT AUXILIARIES

and *N* being normally set to connect these pipes and close off the pipe *U* leading into the generator delivery outlet.

For blowing up the fire in the generator, at starting or after a standby period, the three-way valve just referred to is set to connect the pipes *M* and *U* and block off the pipe *N;* the water-sealed trap *G* is closed; the plug in the tee at the upper end of the large pipe connecting the scrubber with the exhauster *J* is removed, the purge pipe *P* is opened to the atmosphere and the valve at the upper end of the pipe *B* is closed to prevent blowing into the vaporizer. The exhauster takes air from the atmosphere through the now open end of the tee above it and forces the air through the dry purifier, the bypass valve *L*, which yields readily to the pressure developed, the pipes *M*, and *U*, the fuel bed in the generator and out at the purge pipe *P*. During this blowing-up process, the draft through the generator is upward, of course. As soon as the fire is established, the plug is replaced in the scrubber-connection tee, the three-way valve at the junction of the pipes *M* and *N* is changed over, the cock in the waste pipe *R* is opened, the trap *G* is drained, the valve in the pipe *B* is opened and the purge pipe *P* closed off. When gas of the right quality is obtained at a test burner sup-



FIGS. 4 AND 5. PRODUCER CLEANING FLOOR

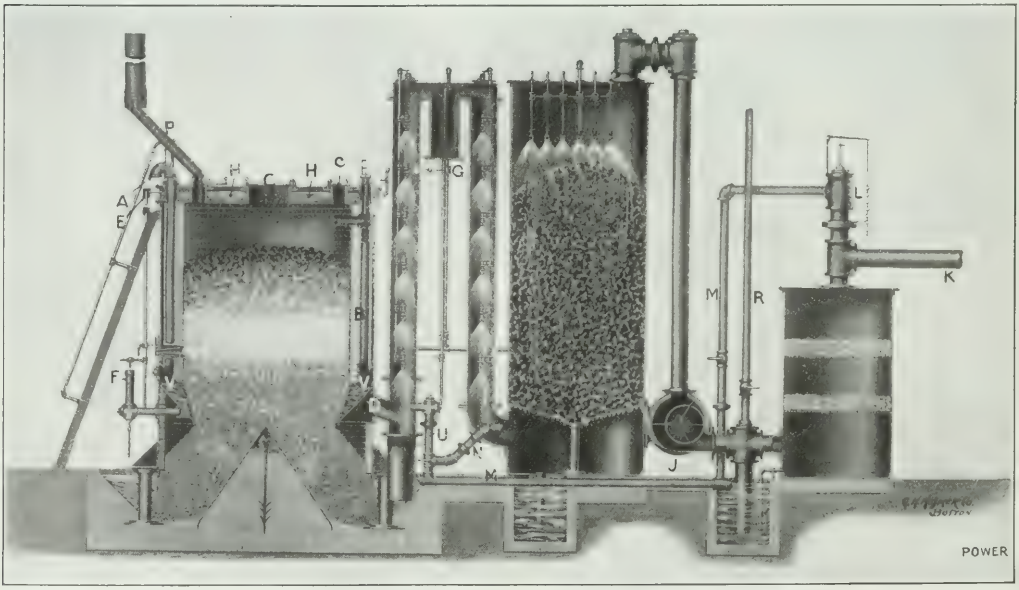


FIG. 6. SECTIONAL ELEVATION OF COMPLETE AKERLUND PRODUCER EQUIPMENT

plied from the waste pipe *R*, the cock is closed and the engine started, unless it happens that the producer is ready before the starting time of the engine; in that event, the pipe *R* is kept open to the atmosphere until starting time, in order to maintain the draft through the fuel bed and keep it alive.

The main engine is a single-acting Otto, working on the four-stroke cycle, and it drives a 50-kw. Allis-Chalmers direct-current dynamo. There are no special features in either machine.

For pumping the water required in the buildings and power house, an air compressor gear-driven by a 10-hp. motor is used. The compressor maintains an air pressure of 70 lb. per square inch in a receiver from which the air is piped down into a 300-ft. well and delivered to the usual deep-well lift. The water is delivered by the air lift into a 13,000-gal. reservoir from which it is pumped up to a general supply tank, 160 ft. above ground, by a 15-hp. motor-driven triple-plunger pump; the motor and pump are connected through rawhide gears. From this supply tank the water is piped to the various buildings about the grounds, through complete fire and domestic water systems.

In starting up the power plant, the small gasoline engine is started and connected to the auxiliary line shaft by a friction clutch. From this line shaft are belt-driven the producer fan, the circulating-water pump and a small air compressor for filling the tank with air for starting the main engine. As soon as the air in the tank reaches a pressure of 200 lb., the compressor is stopped and the gas engine is started with the air. After the engine "takes hold" and the dynamo voltage is brought up to normal, the small electric motor relieves the gasoline engine of the auxiliary load and the engine is shut down.

The plant is operated from 2 p.m. until 10 p.m. Immediately after starting up every afternoon the pumps supplying the water service are set to work and run continuously until the lighting load comes on, when they are shut down. By operating the plant in this manner the load on the generating equipment is practically the same at all hours of the run. The producer operates on common soft coal costing $1 per ton f.o.b. at the mine. The average coal consumption for the 8-hour run is 2.17 lb. per kilowatt-hour, including everything. For cooling the gas and the gas-engine cylinder, 15 gal. of water per kilowatt-hour are used. By using the circulating pump shown in Fig. 3, this consumption can be reduced to a much lower figure.

A feature of more than passing interest is that this plant is being successfully operated by an engineer who came directly from a steam plant and took charge without having any previous gas-engine experience.

Rock Filling for Concrete Foundations

By A. G. Campbell

It is the usual practice to build concrete foundations for engines of solid concrete; that is, from a uniform concrete of cement, sand and crushed stone or gravel. Recently the writer inspected a foundation that was under construction for a gas engine and electric generator set for which a method was being used that seemed to be new. Instead of making the foundation wholly of concrete, the erector was placing in it many very large boulders.

The appearance of a section of the

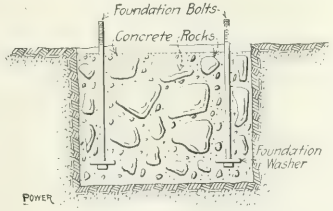


Fig. 1. Boulders in the Foundation

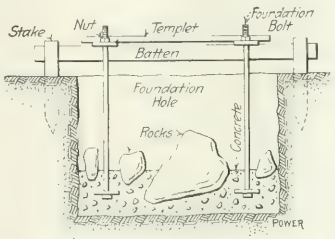


Fig. 2. Method of Building Foundation

resulting foundation is indicated roughly in Fig. 1. The rocks were plentiful in the vicinity and cost only the price of the labor required to get them to the foundation site. Each boulder was wholly surrounded by concrete so there appears to be no reason why the resulting foundation is not as good as if it were solid concrete. The cost of the foundation was considerably reduced through the use of the boulders.

In building, the method suggested in Fig. 2 was followed. The foundation bolt template was supported on battens nailed to stakes and the bolts were carried by the template. A layer of concrete, possibly 8 in. thick, was dumped into the hole and some was packed around each foundation-bolt washer to keep the bolts in place. Then several rocks were bedded in the concrete layer, enough being used to practically cover its entire surface. Sufficient space was allowed between adjacent rocks to permit the concrete to readily settle down between them.

After a layer of rocks was bedded in this way, enough additional concrete was tamped in to cover the rocks. Then another stratum of rock and concrete was placed, and so on until the foundation was complete.

An interesting feature of the foundation which the writer saw built was that no form was used in its construction. The earth in which the excavation was dug was solid enough to be self-sustaining; hence it was not necessary to use forms. The length, width and depth of the hole were made approximately equal to the corresponding dimensions desired in the foundation.

The Big Georgia Gas Engine

By Paul C. Percy

Probably everyone who has kept in touch with gas-power development in this country remembers that a few years ago a 3000-hp. twin tandem gas engine, with a 2000-kw. alternator, was installed in the main power house of the Georgia Railway & Electric Co., Atlanta, to carry the excess load during the peak period every day. It will also be remembered that for several months—about a year, according to report—this engine gave so much trouble that it was almost useless, if rumors were true; indeed, it was reported once or twice as being "down and out," and last December the writer was assured positively that the engine had been permanently shut down and the builders notified to remove the disappointing junk pile.

Thirty minutes prior to writing these lines, the writer was looking at this "down-and-out junk pile" smoothly and almost noiselessly carrying 2200 kw. of the peak load within three minutes after the compressed air had been turned on to start the engine. Far from being a junk pile, the engine is in the finest sort of condition and runs every night with the reliability and unobtrusiveness of a well kept Corliss engine. The rumbling of the big two-to-one gears and a subdued "chug" of each valve as it operates are the only evidences of its activity when one is not looking at it—unless one happens to look at the meters connected to the alternator. During an hour's observation one night and nearly two hours another night, the engine after-fired once, indicating a missed ignition; there was no other manifestation of irregular operation.

The chief operating engineer of the Georgia Co. states that the trouble given by the engine at the beginning was crankpin heating, due to the use of an unsuitable babbitt composition for box linings. After the source of trouble was identified, a softer babbitt was put in the crankpin boxes and there has been no trouble whatever since that change. The reports of cylinder cracks, premature ignitions, etc., are characterized by the chief engineer as being absolutely without foundation in fact.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Blowing Off Heads of Ammonia Cylinder

By R. H. Roark

A short time ago the writer visited an ice-making plant where an unusual accident had occurred.

The equipment partly consisted of a Corliss-engine-driven refrigerating machine, with two vertical single-acting ammonia cylinders of the false-head type. The factory was not operated for three or four months in the fall and a few days before my visit the owners decided to test the ammonia piping and put the plant in operation. The engine was started, with the throttle "barely cracked" (?) and the engineer had walked across the room to the ammonia receiver, when there was a loud report, followed a few seconds later by another.

When the machine was stopped it was found that the heads of both ammonia cylinders had been blown off and broken into fragments. All of the studs were broken off, but the cylinders were apparently uninjured. A 2½-in. extra-heavy flange union was broken by the flying pieces of metal and one of the cast-iron water jackets was broken, presumably by falling fragments of the cylinder heads.

The regular engineer usually neglected to close the discharge stop valves when shutting down the machine and he was careless about seeing that they were open when the machine was to be started. An engineer was hired to assist him who followed a different procedure; he always closed the stop valves when the machine was not in operation. On this occasion the new man had closed the valves without notifying the regular engineer, who started the machine after a careless examination.

This accident was rather unusual in that both heads were blown off. I have heard of several accidents when one head was blown off, but in these cases the engineer had succeeded in stopping the machine before the other head gave way.

This accident points out two very important lessons to engineers: First, that no engineer should make any changes in the usual methods of operation without notifying the engineers working with him. Second, one should always be sure before the engine is started that the machinery attached is ready for operation. While this is a very simple precaution, I have known of several cases where experienced engineers have started up ice machines without first seeing that the discharge stop valves were open.

In one instance, the pressure in the cylinder caused leakage at the joint between the cylinder and cylinder head, this leakage being so great as to attract the attention of the engineer, who closed the throttle in time to save the heads and the charge of ammonia, besides the loss that would be caused by a shutdown in the middle of the summer.

In another case, the steam pressure was rather low and the engineer was unable to start the machine. On investigating, he found that the discharge stop valves were closed and the suction stop valves open.

At another plant the engineer was not so fortunate; he lost his head and opened the throttle wide and jammed it so tight that it was necessary to use a wrench on the valve-stem wheel in order to close the valve. The fireman stopped this machine by closing the main stop valve in the steam main.

Several years ago a similar accident happened that was really a blessing in disguise, as it served to give the owners of the plant a scare that they will never forget. This was a small factory and the owners were also the engineers. The boiler was a lap-seam affair of uncertain age and pedigree and was adorned with a safety valve that was rusty, corroded and otherwise disfigured, but it was undoubtedly the strongest part of the outfit. The engine room equipment contained a double-acting refrigerating machine driven by a Corliss engine that was about twice as large as was necessary. As the safety valve was known to be worthless the fireman was cautioned to never let the steam pressure exceed 80 lb., which was supposed to be the safe working pressure.

All went well until one day it was necessary to stop the machine for a few minutes and the engineer called the fireman to assist him in making an adjustment of some part of the engine. After it had been stopped a short time the engineer stepped into the boiler room and was horrified to see that the steam gage indicated a pressure of 125 lb. Rushing to the engine he quickly opened the throttle, hoping to reduce the boiler pressure to normal. The machine made a few revolutions and then commenced to slow down. In desperation the owner-engineer spun the valve wheel, opening the throttle wide. After two or three more revolutions the connecting-rod on the compressor side of the unit pulled in two, as the discharge stop valves were closed and the rod was the weakest part.

The owner had a narrow escape, as he gamely faced the flywheel until he succeeded in closing the throttle, and was probably only saved from a flywheel explosion by the fact that the engine was running slowly when the connecting-rod gave way.

In the meantime the fireman was covering the fire with wet ashes and cinders from the ashpit and when this task was accomplished the crew retired to a safe distance to wait for the steam pressure to fall. This converted the owners; they installed a new safety valve and had the boiler inspected and insured before the plant was again put in operation.

Loss of Refrigeration in Brine Line

By G. A. Robertson

The following gives the results of a test to determine the loss of refrigeration in a 2½-in. brine pipe covered with brine-pipe cork covering of 2½ in. thickness. This pipe is about 3 ft. underground. The length of the line is 450 ft.

The test was conducted on Dec. 9, 1911, with an atmospheric temperature of 75 deg. F. There had been no freezing weather previous to the date of the test. Two high-grade registered chemical thermometers were used, graduated in tenths of a degree, the space between degrees being about ¼ in. Deep mercury wells were used and these were set well down in the brine pipe, fittings being placed in the pipe line for this purpose. One well was in the discharge pipe of the brine pump in the engine room, the temperature of which was 80 deg. F. The other well was located in a tee on a riser at the other end of the line, the outside atmospheric conditions being as stated above. A magnifying glass was used in reading the thermometers. A man was stationed at each thermometer and both were read at the same time. The readings, given in Table 1, were obtained.

After the 3 o'clock reading, the positions of the thermometers were changed; that is, No. 1 was put in No. 2 well and *vice versa*. This was done in order to account for any error due to the thermometers.

The revolutions of the brine pump were taken several times during the test and were constant at 37 r.p.m. It was a 7 and 6 by 10-in. double-acting steam-driven single Rielly pump. Before the test the pump was calibrated as follows: The discharge valve of the pump was closed, a pipe connection being made between the discharge valve and the pump. A valve was placed in this line, and was closed the amount necessary to maintain the same brine pressure (80 lb.) on the pump as was carried during the test. The suction was not changed. The pump was started and discharged the brine into a can placed on a platform scales. Two trials were made with the following results:

TABLE 1. THERMOMETER READINGS

Time	No. 1 thermometer in engine room, deg. F.	No. 2 thermometer at other end of line, deg. F.	Diff., deg. F.
1:45	18.4	18.7	0.3
2	18.5	18.8	0.3
2:15	18.5	18.85	0.35
2:30	18.5	18.85	0.35
2:45	18.55	18.8	0.25
3	18.55	18.8	0.25
3:15	18.45	18.85	0.4
3:30	18.55	18.85	0.3
3:45	18.55	18.9	0.35
4	18.55	18.9	0.35
4:15	18.5	18.85	0.35
4:30	18.45	18.8	0.35
		Average =	0.325

On the first 382 lb. of brine per minute were pumped, and in the second trial 380 lb., making an average of 381 lb. In both trials the pump made 28½ r.p.m. and thus averaged

$$\frac{381}{28.5} = 13.37 \text{ lb. per rev.}$$

The density of the brine was 75 deg. salometer at 60 deg. F., and the specific heat was taken at 0.854. The calculation for tons of refrigeration was made as follows:

$$\frac{\text{Lb. of brine} \times 1440 \times \text{temp. diff.} \times \text{sp.h.}}{288{,}000} =$$

tons of refrigeration per day of 24 hr.

At 37 r.p.m. the pounds of brine pumped per minute would amount to 494.7. Substituting in the formula gives

$$\frac{494.7 \times 1440 \times 0.325 \times 0.854}{288{,}000} = 0.686 \text{ ton}$$

The heat transmission coefficient based on this figure is about 0.5 B.t.u. per square foot of outer pipe surface per hour per 1 deg. F. difference of temperature.

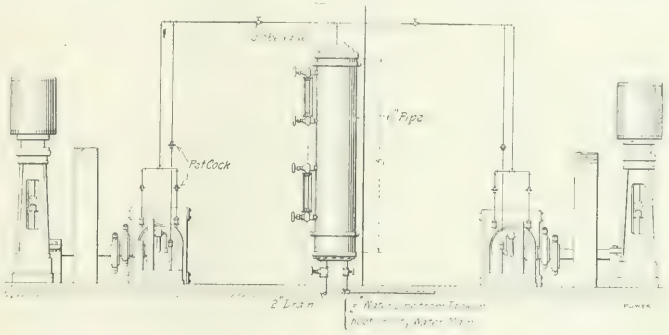
In making a test of this kind it is absolutely necessary that the brine be kept at a very nearly constant temperature; otherwise the readings will be very irregular. The temperature of the atmosphere about both thermometers should be about the same and the thermometers should be set down in mercury wells far enough to fully cover the bulbs. The mercury wells should be set well down in the brine.

Inexpensive Oiling System

By J. H. Stretton

A short time ago I was employed in a refrigerating plant which contained a simple yet effective oiling system. The engines were Corliss, tandem-compound, one right-hand and one left-hand, both being direct-connected to vertical ammonia compressors.

The oil reservoir was clamped to a reinforced-concrete column, and the distributing pipes extended either way over the engines. The illustration shows the arrangement. It may be noticed that oil cups are used, but are not necessary, as the small pet-cocks can be used to regulate the feed. When oil cups are used they act as an auxiliary reservoir in case the system becomes temporarily out of order, the oil cups being then filled by hand. Their use also allows a little more time when filling the main oil reservoir. The system showed in this case a great saving over the old method of filling by hand and costs practically nothing to operate, no pump being needed. The amount of water used is equal to the amount of oil drawn off.



Arrangement of Oiling System

This arrangement has advantages over the gravity feed or the pressure system, as the oil reservoir is down on the engine-room floor and is always in sight instead of being on the roof and requiring to raise the oil to the reservoir, as in the gravity system. A pump is also necessary with the pressure system.

To refill the reservoir, shut the ½-in. valve in the water line, open the 2-in. valve in the drain and remove the plug from the top. When the water has drained out, close the drain valve and fill the reservoir with oil. Then turn on the pressure and the fresh supply will be ready for use at the various points requiring lubrication.

In Switzerland, water power is conserved and utilized to such an extent that in some towns not an ounce of coal is used. Power, light and heat are furnished by water power.

LETTERS

Making Chloride of Calcium Brine

W. L. Keil gave, in Power of Dec. 12, a description of a home-made outfit for making chloride of calcium brine. The next time Mr. Keil wishes to make this brine I would advise him to dump the chloride of calcium right in the brine tank, and he will find that it will melt there just as fast as in the barrels. This may be done when making new brine as well as for strengthening weak brine. In the latter case the brine is generally cold, but the chloride of calcium dissolves just the same. The reason is that chloride of calcium has a strong affinity for water, and will readily dissolve when coming in contact with it.

Chloride of calcium is nasty stuff to handle, and to get it where it belongs the quickest and easiest way is to break it up to the size of run-of-mine coal and dump it in that state right into the brine tank. In 10 to 15 hr. it will have melted away.

Common salt dissolves in barrels or boxes faster than chloride of calcium with water run over it, and the mixture stirred as in making brine, but if in its natural state it is dumped in old brine or water for making brine, it is liable to cake in a solid lump and never dissolve.

Fred Kaiser.

Sanford, Fla.

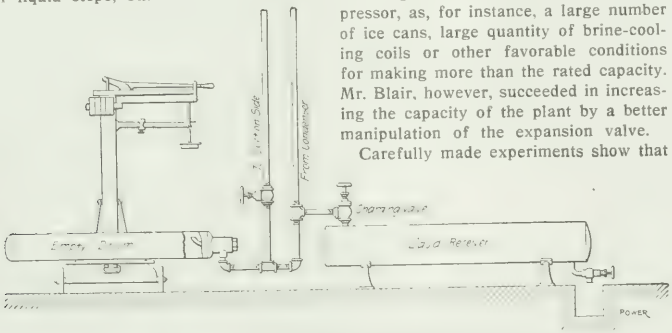
Drawing Ammonia from Compression System

In the Feb. 6 issue the question was asked, how can the ammonia be taken out of a compression plant without losing any of it? While the answer is a good one, my experience with the same problem may be of interest.

To draw a charge of ammonia from the system, connect an empty ammonia drum to the charging valve. Put a tee in the pipe between the charging valve

and the drum and from the branch of the tee run a pipe to some connection on the suction side of the machine if possible. Insert a valve in this line. The curved pipe inside the drum should face upward, as shown in the sketch. Place the drum on a platform scale when all connections are made. Then open the drum valve and the charging valve and allow the liquid to flow from the receiver to the drum. By watching the scale beam it will be seen that the ammonia soon stops flowing. This is because the gas forming in the upper part of the drum has equalized the pressure.

Now shut off the charging valve and open for a second only the valve in the branch line to the suction side. This will allow the gas to pass off and when the charging valve is opened again the liquid will start flowing. This operation should be repeated as often as the flow of liquid stops, but be careful and not



Drawing Ammonia from Liquid Receiver

get any more ammonia in the drum than it contained when new. If it is not convenient to make the connection to the suction side of the system, the gas can be allowed to escape to atmosphere as the amount would not be very great. In this manner the system can be completely emptied.

Martin McGerry.

Holley, N. Y.

Temperature of Ammonia Discharge Pipe

I noticed in Power of Jan. 23 Bennett Story's letter on the temperature of the ammonia discharge pipe, and also how he had increased the capacity of the plant. In my practice I have paid little attention to the discharge temperature as long as I could keep the compressor working well. I feel safe to say that there are more engineers who keep their discharge temperature too low than otherwise. I do not believe in trying to make the compressor do its own work and the condenser's also.

I wish Mr. Story had given a few more details of the kind of plant he has and other conditions. He states that he runs the discharge temperature lukewarm. This is an unknown quantity. Webster gives it as moderately warm, not excessive, so that it might fit quite a range of temperatures. The article by Mr. Blair, in the Oct. 31 issue, in which he says he increased the capacity of his plant from 33 to 50 per cent. by closing the expansion valve, makes me think of the story of the man who wanted to buy two stoves because he was told that one would save one-half the fuel.

Frank H. Cordner.

Bradford, R. I.

In his letter Mr. Story does not say that he increased the output of the plant by a particular manipulation of the expansion valve. He says that they made 40 tons of ice with an ice-making system rated at 30 tons and 26 tons with a system rated at 20 tons. This may have been due to causes other than those resulting from the operation of the compressor, as, for instance, a large number of ice cans, large quantity of brine-cooling coils or other favorable conditions for making more than the rated capacity. Mr. Blair, however, succeeded in increasing the capacity of the plant by a better manipulation of the expansion valve.

Carefully made experiments show that below a certain temperature of discharge, which temperature varies for different sets of suction and discharge pressures, the capacity of an ammonia compressor for pumping gas decreases. To secure the best average results the discharge temperature should be kept well above this limiting point to allow a reasonable fluctuation in the quality of the suction gas without reaching extreme conditions either way and thereby impairing the efficiency of the plant.

For 185 lb. condenser pressure the average discharge temperatures should be about as follows:

	Deg. F.
25 lb. suction pressure	215
15 lb. suction pressure	250
5 lb. suction pressure	275

In a general way it might be said that the proper temperature of discharge for an ammonia compressor is the theoretical discharge temperature for the pressures under consideration, the suction gas being saturated. The decrease in the capacity of the plant when the temperature of discharge is low, is due to the excessive quantities of liquid present in the suction gas, which decreases the pumping capacity of the machine per revolution.—Editors.

Ammonia Packing

I see in Power of Feb. 20 that H. G. Gibson has had trouble in packing the piston rod on his ammonia pump. I know how to sympathize with him for I had tried to pack a similar rod for a couple of years before I won out. Let him stop entirely the use of fibrous packing and use instead a ring of good rubber 3/8 in. thick, then a ring of babbitt metal 1/8 in. thick, another rubber ring, then a babbitt ring and so on until the box is filled on both sides of the lantern.

H. A. Greene.

Boston, Mass.

Take good hemp packing of the correct size, neither too large nor too small, and wind it around the rod to be packed as many times as there are rings required, care being taken to keep the coils tight and pressed close together. Now draw a straight line from the end across the coils of packing and parallel with the rod. Take the packing off the rod and cut with a sharp knife at each mark. Take the pieces cut, which should be of the correct length, and tie a string around them, making a small bundle. The bundle should be soaked in good ice-machine oil over night, and then pack the pump, using no other lubricant in the stuffing-box.

R. P. Wilcox.

Chicago, Ill.

After using fibrous packings for several years and having the rods leak at the end of a few days, I tried several methods and combinations of packing with the result that I spoiled the rod.

I had always used a pure gum ring as a condenser-tube packing, and decided to give it a trial on the pump. I have found this packing satisfactory. It must be supplied with oil, and in our case a swab was placed on the rod and fastened so that it could not travel. An oil cup was tapped in at a convenient place and one or two drops of oil per minute were allowed to drop on the swab.

This method can be employed most anywhere, and while the first cost of the gum ring is about twice as much as the fibrous ring, the amount used is less, and the rod is saved.

H. H. Burley.

Brooklyn, N. Y.

We have had exactly the same trouble as Mr. Gibson. We used the same kind of packing, the solid rings and the diagonally split rings alternately, but with no success. The packing would crumble. We concluded that the packing was too soft and so tried a tougher packing which comes in long spirals and is made with alternate layers of rubber and canvas.

It is giving us entire satisfaction and I would advise Mr. Gibson to try it and let us hear further from him.

Frederick M. Perras.

Mansfield, Mass.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
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Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20 1910, at the post office at New York, New York. under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 32,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Engineering in the South

As has been often said, "the world moves rapidly," but it is impossible to form an adequate idea of just how fast it does move without inspection at close range. That is why at frequent intervals a member of our editorial staff buys a multicoupon railroad ticket and, taking his notebook and pencil firmly in hand, migrates north, east, south or west, returning with a vastly broadened knowledge of the section of country traversed, together with particulars of power-plant practice contributed by engineers of that section.

The last time, the editor went into the "Sunny South," and some of the results of his pilgrimage are presented in this issue. These articles, however, do but faint justice to the astonishing development that has characterized the past decade in that section. Power plants formerly consisting of a few belted units and return-tubular boilers have grown into equipments of turbo-generators supplied from water-tube boilers; picturesque falls and rapids which were formerly regarded only as scenic attractions are now the primary dependence of economic manufacturing, well lighted streets and enhanced domestic comfort in near-by cities.

Ten years ago the populace of New Orleans crossed the streets on planks during heavy rainstorms and even then did not "land" dryshod; drinking water was laden with typhoid and yellow-fever germs during certain seasons, and open sewers were a constant menace to health. Today, the surface water is taken off and forced out into the lakes by large motor-driven pumps, the city operates a huge water-purifying plant, and practically all domestic refuse is pumped away through closed sewers. The power equipment of the drainage system is described elsewhere in this number.

A very interesting feature of practice in one of the large central stations of the South is the operation in parallel of high-tension alternating-current generators driven by four different types of prime mover; a brief outline of this is given in the Electrical Department. At another large station most of the units are operated noncondensing in order to utilize the exhaust steam for commercial heating throughout the business district. A small station in Georgia is operated by gas engines supplied from producers which are charged with pine blocks and cypress roots and stumps.

These and other evidences of the engineering development of the South are presented in the present number. Even the citation of all such examples of Southern modernity would be utterly impractical. Our efforts, therefore, have been restricted to the discussion of a few representative installations, as diversified as possible in character. These suffice to show that in engineering, as in other matters, Dixie-land, far from being under the domination of the hookworm, is thoroughly alive to her opportunities.

The Dividing Line

It is unfortunate that there is so little available information as to the actual cost of steam power-plant operation. In the controversy between the advocates of the isolated plant and those interested in the extension of central-station service no authentic figures are given, and when an owner is compelled to make a choice between the two systems it is usually the best talker who gets the business, regardless of the facts involved in the case.

There is, of course, some dividing line in the power requirements above which the isolated plant will give the cheaper service and below which it will be profitable to buy power.

There are several factors that enter into the power-plant problem, not the least of which is heat. In many industries this is needed the year round, and in all northern latitudes for at least half of the year, and the ratio of fuel required for heat to that necessary to furnish the required power should be considered.

The cost of labor in a small plant is proportionally higher per unit of output than in the large one. A steam-power electric plant of fifty kilowatts capacity will require the employing of an engineer and a fireman, which would make the labor cost alone approximately one cent per kilowatt-hour. Coal and fixed charges would probably increase this to nearly four cents for a constant load for three thousand hours per year and it might easily be double this for a plant where the maximum output is reached only during the lighting period.

For a plant of one-half this capacity the total labor cost could not be much less, but the cost per unit of production would be doubled and would reach a price which would be readily met by the central station.

As the plant increases in capacity the cost of attendance per unit of output rapidly decreases, and in many large plants the labor cost per kilowatt-hour is an insignificant fraction of a cent.

In the central station there are large distribution expenses to be met which do not obtain in the small plant. There are some at or near the fifty-kilowatt line where the costs will balance and above which the isolated plant will have the advantage, while below this line purchased service will be the cheaper.

The calls for steam for purposes other than for power will have a modifying influence and may in some cases make even the smallest load a profitable one to carry.

Structural Errors

It is to be regretted that engineers and power-plant men in general are so often compelled to labor in small spaces where it is almost impossible to accomplish the work to be done without loss of temper and very often minor injuries to the body. It is true that the ability to meet such conditions is what is required of an engineer, but that is to his credit, and does not justify the conditions that call for the exercise of his skill in this direction.

Of course, it is not always possible to prevent the existence of such places in power plants, and it is also true, once in a while, that the architect is not to blame. Where space is very valuable, the architecture of the plant must be adapted to that condition. In such cases the engineer must tolerate the discomforts and hardships imposed, and accomplish his task as best he can.

Unless one has experienced the work of firing in a poorly ventilated boiler room during a hot day, when the load is usually heavy, it is difficult to imagine its discomforts. Then, too, there are those small, cramped quarters where the auxiliaries are often located, and where making repairs or adjustments is well nigh torture.

Wherever conditions will allow it, the design of a power plant should be such as to give space enough around each piece of machinery to facilitate attendance and repair instead of aiming in the opposite direction, as the conditions in many plants would suggest had been done.

Possibilities of a Coal Strike

Engineers and plant owners who have had their ears to the ground feel that a strike among the coal miners is not only possible but probable. That the trouble will extend to the entire bituminous coal fields in the United States is doubtful, but that the anthracite miners will strike Apr. 1 is almost a foregone conclusion.

The situation is intensified because the existing agreement between the anthracite and bituminous coal miners and the operators expires at the same time, Apr. 1.

A strike means much to all concerned. Not that there will be a suspension of business, such as England has experienced, but if the users of the smaller sizes of anthracite coal cannot obtain a sufficient supply, bituminous coal will be substituted at an increase in price and with its accompanying smoke production.

Those who have had the foresight, and whose circumstances have permitted, have stored coal in anticipation of a shortage. Those who have not the facility for storing fuel will find it necessary to modify furnace and grate conditions and make arrangements for burning soft coal, of which there is an overproduction.

In the event of a strike it is doubtful if it extends over a long period. Public sympathy is not with the threatened suspension of mining because the miners demand a 20 per cent. minimum increase. This practically means a wage of $3.50 per day and an increase of about 65 cents in the cost of domestic coal per ton, will come out of the pocket of the consumer.

A strike will mean an increased consumption of soft coal and an increase in cost. This will ultimately result in a higher cost of living which, in the minds of the public, is altogether too high as it is, without additional burdens. A strike to succeed must have the sympathy of the public; without that, it is bound to fail.

Although indications do not point to a long-drawn-out strike, a big reserve supply at the rear of the boiler plant will materially assist in preventing a shutdown and suspension of business due to failures of cargoes to arrive on time.

Wave Motors

Another wave motor is announced on page 443 of this issue. The problem of converting the energy contained in the moving mass of water which constitutes a wave is rather a financial than a mechanical one. There are many ways of doing it, but none has met with any extensive adoption because the interest on the cost of the installation would more than pay for coal enough to produce the derivable power.

It is often questionable whether it will pay to dam a river and develop the power of a continuous water supply. The same careful consideration of the relation of interest and depreciation charges to power producible should precede any investment in a wave motor. The denominator is apt upon analysis to be unexpectedly small.

An entrance examination is proposed for candidates for admission to the Institution of Mechanical Engineers of Great Britain. Such examinations have long been in force in the Institution of Civil Engineers and are proposed for the Electrical Engineers. The rules are flexible enough to permit the admission of a man of sufficiently wide practical experience, notwithstanding a lack of institutional education. So far as we know, no such examinations are required in any of the American national professional societies in the engineering field.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Working a Bag Out of a Boiler

I was recently called upon to work a bag out of a boiler. After examining the boiler, I found the bag to be 17 in. in diameter and 2¼ in. deep. I drilled a hole in the center, to allow for take-up and cleaned the plate off nicely both inside and outside, and then heated the plate to a red color, placing fireclay mixed to a putty in the center so as not to overheat at that point. I was very careful not to overheat the plate at any point.

Then, with a smooth face flatter and a medium-size sledge, I drove all around the center, working the bag up. Several heats were necessary to get the plate back to the original shape. I used a straight-edge to determine when the bag was out and the plate in shape. I drove the plate so as to bow a little inward.

After this was accomplished, I reamed the hole out, which had partly closed and heating a rivet of proper size, placed the head on the inside and riveted up the hole. I then gave the boiler 90 lb. per square inch of cold water test and hammered lightly on the repaired boiler, which showed no stress or strain. After dropping the water to a proper level, the boiler was fired up, the job being perfect in every respect.

E. L. Morris.

Salem, Va.

Centrifugal Pump Trouble

We are pumping some 2500 gal. of water per minute carrying about 8 per cent. solids through a 10-in. pipe line 2000 ft. long, and raising the water and solids some 70 ft. To do this, at times we have three 10-in. centrifugal sand pumps in the line. One pump is placed at the lower level, the other two are placed at such locations as to divide the head equally between the three pumps.

We have had considerable trouble in the breaking of the upper pumps when starting up or shutting down, due to the separating and closing again of the column of water in the line. Of course, if all three pumps could be controlled simultaneously, the trouble would be eliminated. One solution is to discharge the water from the lower pump into a small reservoir or sump hole near the suction of the upper pump and pick it up again. This, however, necessitates a complication of suction and priming connections and foot valves which it is desirable to avoid.

We have tried check valves in the line to hold the column of water from flushing back toward the lower pump. This has proved of no avail as the check valve holds a stationary column of water on its upper side which has enough inertia to cause immense pressure due to impact when the lower column hits it. We have also contemplated installing relief valves at suitable points in the line, but the difficulty of keeping the valve seats, and other parts in good condition due to sand, rock, etc., in the water has deterred us heretofore. We are now contemplating placing air chambers at the discharge of the pump to cut down the jar due to the making and breaking of the column of water in the line.

Possibly our experience may be of interest to Power readers, and its discussion may be of benefit to those interested.

Milton Baker.

Plant City, Fla.

A Wave Power System

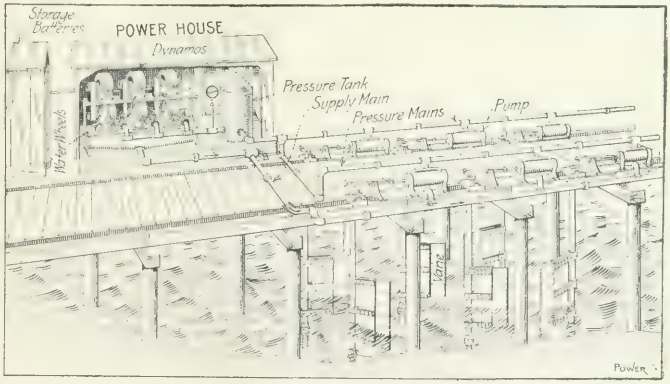
In a recent number of Power, there appeared an exhaustive article by Franklin Van Winkle, "Power Derivable from Ocean Waves." He states that the possibilities of obtaining commercial power from a wave motor are founded on a very narrow margin. I will go farther than that and state that they are practically out of the question. Mr. Van Winkle has made the same mistake that all inventors and engineers have made ever since the history of the wave-motor question began, viz.: That of considering the problem from the standpoint of the individual motor.

The inclosed prospectus will introduce the question in an entirely new light, as it deals with the problem from the standpoint of a system.

F. M. Reynolds,
Secretary,
The Globe Wave Power & Electric Co.
Long Beach, Calif.

[The accompanying figure, taken from that shown in the prospectus, serves to illustrate the principle of the "system" mentioned.

The submerged vanes actuate the pumps which force water into a pressure tank from which the water flows to the waterwheels that run the dynamos.—Editors.]



The New Wave-power System

Cut the Boiler Shell

The danger of using sharp tools in cleaning the inside of a steam boiler was proved to me a short time ago.

The boiler in the plant where I have been employed as general mechanic for two years, had for four years been equipped with a boiler scraper, making it almost if not quite impossible for the engineer to get inside under the tubes to do the cleaning properly.

The damage must have occurred over four years ago, and before the scrapers were put in. The engineer on firing up the boiler one Monday morning noticed a small leak in the rear sheet, about 3 ft. from the rear head, at the point where the brace from the head is riveted to the sheet. At 40 lb. pressure there was a stream of water and steam as large as a lead pencil pouring into

the combustion chamber. The engineer at once pulled the fire and began to cool the boiler.

As soon as it was cool the scraper was removed and thrown away. Seven tubes were then removed when it was found that the crack was directly under the heel of the brace. The brace was then taken out and in place of a crack we found that the shell had been cut some time by a sharp tool as it had been driven under the brace to remove the hard scale.

The cut started from each side of the brace, which was 4 in. wide, at about 1 in. back from where the heel of the brace met the iron. It extended at a slight angle to the rear, one cut overlapping the other about ¼ in., and from a scratch at the beginning to fully ¼ in. deep where they met in the center.

The inspector claimed it had been caused by the expansion and contraction of the metal, but as there was a metal chip lying over and partially closing the first cut where they came together, it must have been caused by driving something under the brace.

Six ½-in. holes were drilled and tapped, copper plugs put in and headed over nicely; the brace and tubes were replaced after they had been trimmed and welded, and when the boiler was put into commission again it was as good as ever.

It is a good plan not to use sharp tools or tools with sharp corners around boiler shells in scaling; but if it is necessary, be careful where the edge or corners of the tools go, or a leak, if not worse, may result.

A. H. STRONG.

Los Angeles, Calif.

Steam and Temperature Charts

The accompanying charts from a recording steam gage and a recording flue-gas thermometer graphically illustrate the importance of proper construction and operation of boiler furnaces. These charts were obtained from an 18-ft. by 72-in. return-tubular boiler, set in a brick furnace. It was operated 12 hours daily, at two-thirds of its rated capacity.

The fire was stopped at about 5:50 p.m., as shown by the chart, Fig. 1. The steam pressure was 115 lb. at 5:45 a.m., there having been no fire in the furnace during the intervening 12 hours.

Oil is used for fuel and about two minutes before the engine is stopped for the night the supply of steam and oil to the burner is shut off and the ashpit doors and damper are closed, but the feed pump continues to run. As soon as the engine is shut down the main stop valve on top of the boiler is closed, the feed pump being supplied with steam from a small auxiliary line.

The feed pump is permitted to run until the boiler contains about three gages of water, which pulls the steam down to 95 lb. The feed pump is then stopped, all valves in the feed line are closed and the steam is shut off from the auxiliary header.

When the feed pump was stopped at 6 p.m. the steam pressure commenced to rise, caused by the boiler absorbing heat from the hot brickwork of the furnace, until at 7 p.m. the safety valve opened. The fall of pressure between 7:15 p.m. and 5:45 a.m. was regular and gradual, being caused mostly by the radiation of heat from the boiler and furnace.

The bulb of the recording flue-gas thermometer is inserted in the smokebox directly above the tubes, and the thermometer chart, Fig. 2, shows that the temperature in the smokebox fell at a rate corresponding to the fall in steam pressure.

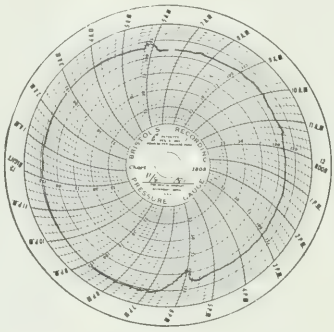


FIG. 1. STEAM CHART

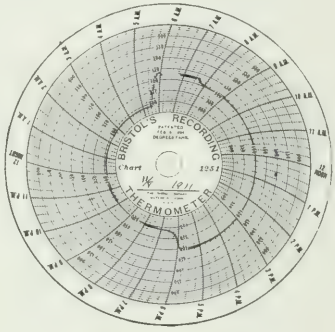


FIG. 2. TEMPERATURE CHART

I have seen plants where the steam pressure would fall to zero a few hours after the fuel oil was shut off, owing partly to leaky steam and water valves, but principally to a leaky furnace setting and leaky ashpit doors and dampers, which permitted cold air to be drawn in through the tubes, cooling the water and condensing the steam in the boiler.

This is poor economy, for fuel is wasted in heating the furnace and raising steam to the working pressure in the morning.

J. T. WILLIAMS.

Brownsville, Tex.

Effect of Air in Steam

I would like to have some practical and theoretical opinions as to the effect air in steam may have on the vacuum in a condenser.

Would not a leaky suction on a lifting boiler feed pump affect the vacuum more than a leaky condenser pump on account of the higher temperature of the air coming from the boiler?

W. A. FULLGRAF.

Collinsville, Okla.

Repairing a Cracked Cylinder Head

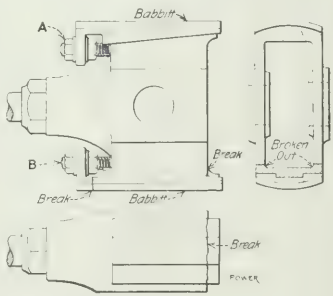
Cylinder heads of pumps become broken sometimes. A simple way to repair one while waiting for a new part can be accomplished in the following manner: Remove the broken head and cut a piece of galvanized iron the exact size of the head and place it between the packing and cylinder head. Then tighten up the stud nuts holding the head, and the pump is ready for work, providing no further trouble exists.

STANLEY RADCLIFFE.

Laurel, Md.

What Broke the Crosshead?

The accompanying sketch shows a very peculiar break of a crosshead of a 10x 30-in. Corliss engine, belted to two 35-kw. generators. The engineer had packed the piston a few minutes before starting up for the night's run. He started up and the engine had no more than gotten up speed when there was a loud report. It was found that the crosshead and bottom shoe were broken, as shown. When



BROKEN CROSSHEAD

the engineer shut down he found that both guides were hot and the crosshead shoe was out on the floor.

I do not understand what caused the trouble as the nuts *A* had not been taken up in six months. The engine has been in operation about 10 months and ran at 90 r.p.m.

The bolt *B* was bent up toward the piston, but was not broken, and both nuts were tight. The crosshead was patched, a brass shoe made and put on and it has been working very nicely since.

Can someone who has had a similar trouble and found out what caused it let me know?

H. R. Williams.

Grand View, Tex.

To Remove Burnt Oil

For several years I have used the following recipe for removing burnt grease from the bright parts of engines, such as cylinder heads and valve bonnets.

Dissolve about 5c. worth of oxalic acid in 1 qt. of distilled water and apply with a rag while the metal is either hot or cold.

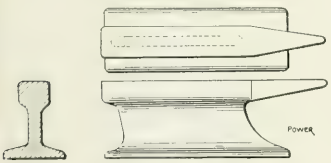
Some engineers are troubled by oil sticking to the sight-feed glass on lubricators. One remedy is to clean the glass thoroughly and refill it with glycerin. It will not only keep the oil from sticking, but the oil can be fed in small, round drops. Keep the packing nuts tight and fill the lubricator each time before it runs dry, and the glycerin will stay in the glass indefinitely.

D. E. Aden.

Wilburton, Okla.

Rail Bench Anvil

While visiting a neighboring plant my attention was attracted to a small bench anvil. It was made from a piece of steel



Anvil Made from a Piece of Rail

railroad rail tapered at one end as shown

J. H. Stretton.

Los Angeles, Calif.

Low Water in Boiler

In a plant where I was acting as night engineer, there was a battery of five boilers. On entering the boiler room one night, I found the head fireman asleep, and his helper firing in his place. I looked at the water gages and could see no water in No. 4 glass. On trying the column and getting no water, I ordered the helper to pull the fire while I went behind the boiler to open the back door. While I was doing this, the fireman awoke and turned the water into the boiler. It seemed to me that the boiler jumped an inch from the floor; there was a muffled report, and the helper said the steam gages went up 5 lb.

The water put out the fire, and on examination I found 45 flues sprung in the tube head. The feed water entered the boilers at 195 deg. F., and it is my opinion that the boiler would have exploded if the tubes had not sprung and relieved the pressure.

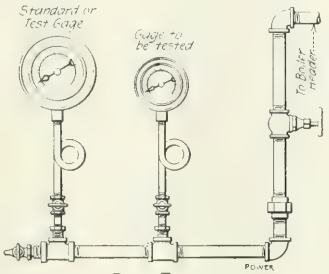
I do not want any more conclusive proof that water in an empty boiler will cause an explosion.

V. C. Wood.

Copenhagen, N. Y.

Gage Tester

There are 50 odd steam, air and water gages in constant use about my plant, and I keep them accurate by testing with a home-made gage tester, which is always ready for use. It is connected up as shown in the illustration.



Gage Tester

The water gage is tested every two or three months by the same boiler inspector. I can test gages at different pressures by throttling the valve in the steam line and opening the drain cock at the end until the desired pressure is obtained.

With this device I keep all gages in perfect working order with very little trouble and expense. The pipe can be connected to the boiler steam header or to a water tank if the pressure is enough.

J. W. Dickson.

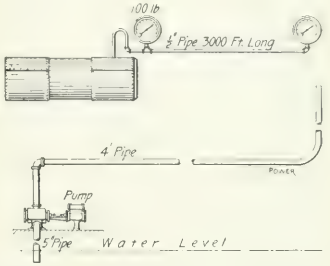
Memphis, Tenn.

Three Pressure Problems

There are three problems which I would like to have the readers of Power solve. The first is, What is inside of the spring of a steam gage, steam, air or water?

Second. With 100 lb. pressure (gage) on a boiler, what pressure would a gage show when placed 3000 ft. away on the end of a ½-in. pipe with the pipe level, no leaks, no outlet, and the gages at the same elevation with the pipe full of water? (See Fig. 1.)

Third. A 10 and 6 by 12-in. duplex, outside-packed, plunger steam pump is fitted with a 5-in. suction pipe and a 4-in. discharge pipe. The steam at the throttle is 100 lb. and the suction lift is 5 ft. The head on the discharge pipe is 5 ft.; that is, the end of the pipe is bent to an angle of 90 deg., or at right angles to the horizontal pipe. What length of pipe would be required so that when placed level with the open end up in the air or vertical, no water would flow from the end with the pump running with a wide open throttle? The slippage is assumed to be 20 per cent. and no allowance is made for friction of the pump pistons. (See Fig. 2.)



Figs. 1 and 2. Piping of Gages and Pump

The first question has been discussed all winter at an engineers' association and is still unsettled.

Question two is asked to learn what, if any, difference in pressure there would be between the steam gage on the boiler and one in the engine room some distance away, as is the usual case.

Question three is asked to determine whether a pipe could be long enough so that the 10-ft. static head plus the friction of the open-end pipe could increase the load enough to overcome the 100 lb. steam pressure.

J. C. Hawkins.

Hyattsville, Md.

Cut Engine Cylinders

A call came from a large power plant to a firm of engine builders to send a man to bore out a 32-in. cylinder. It was found that before reboring the cylinder it would be necessary to put on a patch, as the cylinder was cut entirely through at the top; the sides showed some wear but the bottom had hardly any.

A copper patch was put in and the cylinder was rebored. The engine was then put into service again and a sharp lookout kept for results. Some days afterward the cylinder head was again removed and signs of new cutting were apparent.

Several theories were advanced as to the cause of the trouble. The same kind of oil was being used in other engine cylinders running under the same general conditions, and steam was supplied at 160 lb. pressure, superheated to 480 or 500 deg.

A suggestion was made that turning a little off from the sides of the rings

to make them freer in the grooves might help matters. This was done and proved to be a remedy.

A similar case cost this same engine company a new engine cylinder, to replace one which was cut so badly in a short time as to require reboring.

After running some days, the same thing happened again, and the purchasers demanded a new cylinder; it was furnished.

Imagine their surprise when the cutting started again. Finally, the piston rings were reduced $^1/_{16}$ in. in width, and no further trouble was reported.

The cutting was done mostly on the head end and stopped about where the cutoff would occur at normal load. This was doubtless due to the fact that at the end of the stroke before the boiler pressure was admitted, the ring was free to expand, which it did. When boiler pressure was admitted, however, the pressure on the follower was sufficient to grip the ring, whose edge acted as a scraper until the pressure was cut off, which, becoming less, released the rings.

H. R. Low.

Moosup, Conn.

What About the Receiver Pressure

The accompanying diagrams were taken from a pumping engine which I think are about right. I would like to know

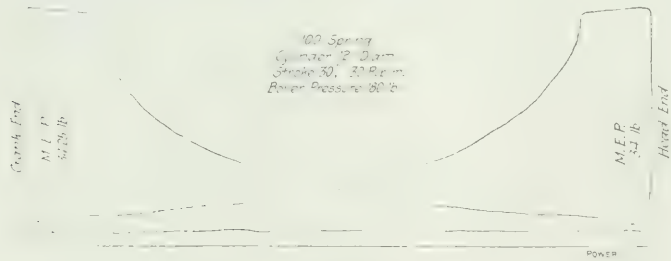


FIG. 1. HIGH-PRESSURE DIAGRAMS

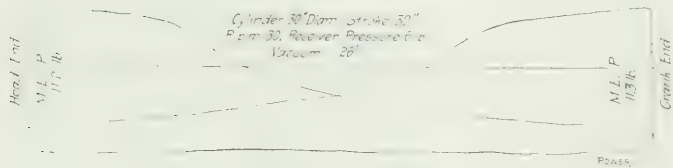


FIG. 2. LOW-PRESSURE DIAGRAMS

if any reader has any suggestions as to the receiver pressure carried, which is 6 lb. per square inch. Is equal work done in both cylinders?

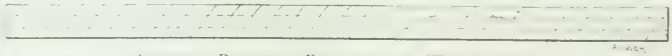
Notwithstanding that our engine runs very smoothly, it will be noticed that there is very little compression.

J. F. REYNOLDS.

Phoenix, Ariz.

Peculiar Gage Glass Fracture

The accompanying illustration represents a water glass recently removed from a boiler water column. The sketch



SHOWING PECULIAR FRACTURE OF WATER GLASS

shows the manner in which the glass broke, the spiral and the divisions being as near a duplicate of the actual glass as it is possible to make.

RICHARD SWARTZ.

Hot Springs, Ark.

Locating a "Screech"

I was installing a small high-speed engine and fan in the boiler room and having paid a visit to the maker's works to see the engine tested, I expected no trouble with it when starting up.

I arranged for a trial run immediately after stopping-time to make sure of a good send off the next morning. When I turned on steam, running the engine slowly, I also turned on an awful screeching. As the screeching synchronized with the stroke of the piston, I had the cylinder cover removed and an abundant supply of thick oil was poured in, but this did not improve matters.

The cover was again removed and the piston tested for clearance; using feelers I found a variation from 0.003 to 0.007 in., and concluded that an error of 0.004 in. would not cause such a noise. Then I removed the piston, and as the rings were somewhat stiff I had them relieved slightly on the inside.

As this made no improvement, I concluded that something was wrong with the piston or connecting-rod, and I had them out for a proper examination, but found them all right.

Although I had not located the trouble, I told the men to get the engine together again, but there was not the slightest improvement. With both hands on the valve wheel I turned off the steam and the screech seemed to vibrate along my arms. Upon removing the globe stop valve, I found the valve stem over which the disk fitted much too tight, the spinning of the disk setting up the screech which puisated with the piston-valve movement. This was soon put right and we made a good start in the morning.

I had saved $6 by purchasing that globe valve separate from the engine. On the other hand, I had to pay two pipe fitters and a fireman for the all-night work, and there were my own time and loss of sleep, a new suit, salve for various scalds and the coal I did not save that night.

F. P. TERRY.

Belfast, Ireland.

Damper Regulator

I would like to see the following questions discussed by the readers of POWER:

Is it economy to use damper regulators operated by steam pressure?

Is it not true that when a damper opens a poor fire is the direct cause and will this not cause the furnace to chill and produce a low percentage of CO_2? Further, would not a regulator operated by a CO_2 apparatus produce a greater saving than when operated by other means?

G. CLINTON SMITH.

Iron River, Mich.

Question Reference Book

I have experimented with index question books for some time and I am now trying a system that appears to me the best of which I have seen or heard. The book fits the vest pocket and gives a leaf 2½x4½ in. The paper is thin and can be used on both sides.

The questions are grouped and numbered; for instance, under "Boilers" I group "braces," "heating," "rivets," and so on.

Over the question I write in red ink where the answer may be found, as, for instance, POWER, Vol. 34, page 44.

Whenever I find a question, I make note of where I can find the answer, as this is much easier than writing out the answers.

L. N. WEBSTER.

Springfield, Mass.

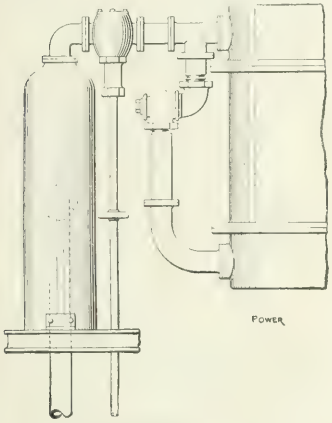
Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

What Cracked the Ell

In answer to Mr. Blessing's request in the Feb. 13 issue, I offer the following:

If the distance from the center of the tee to the center of the ell does not measure exactly the same as the openings in the cylinder, a slight strain would be caused in connecting up the pipe, and



PIPING ARRANGEMENT TO TAKE UP EXPANSION STRAINS

when expansion takes place instead of the expansion joint acting as a relief, it creates an increased strain, causing the ell to break.

If the measurements are correct, a longer expansion joint would remove the cause. I suggest, if the conditions will permit, that Mr. Blessing place the tee closer to the cylinder, breaking down with a close nipple and ell, making a swing joint as shown in the accompanying figure, and doing away with the expansion joint.

I had a similar case seven years ago, and the swing joint gave the desired relief.

EDWARD L. JOHNSON.

Brooklyn, N. Y.

In the Feb. 13 issue, H. R. Blessing wants to know why the ell breaks on a pipe which is supposed to be protected by an expansion joint.

An expansion joint will very often fail to operate in a position such as is shown by his drawing. The joint is not in a straight line between the two ends of the piping intended to be protected. Therefore, if the expansion joint sticks ever so little, the expansion will bow the pipe out enough to bind the joint so that it cannot slip no matter how much pressure comes on it. The greater the pressure, the harder it will bind.

Even if an expansion joint has lateral play enough to prevent its binding, it is often the case that the friction necessary to make it slip is greater than the force required to bend the pipe.

All pipe lines containing bends or elbows should be thoroughly braced in a straight line with the section containing the expansion joint in order that the latter will be forced to do its work.

FRED BOONE.

Davidson, Okla.

The sketch in Mr. Blessing's letter in the issue of Feb. 13 shows a receiver-separator approximately 10 ft. high mounted very close to the engine cylinder and rigidly fixed at the bottom so that its expansion would raise the outer end of the short upper connection, thereby forcing the expansion joint away from the cylinder and putting a bending moment at the point where the crack appeared.

When steam was turned into the cylinder, the expansion of the cylinder would tend to relieve the stress, or might even reverse it by lifting the cylinder end of the pipe higher than the receiver end. In any case, some bending force was applied as often as the cylinder was heated and cooled.

There is some evidence to show that cast-iron fittings slowly deteriorate when subjected to high steam pressures, especially if superheated steam is used and the temperatures are intermittent. Such conditions are likely to be found in plants of this size and it may be that deterioration of this sort was a contributing factor. Again, the engine when running has some vibration and perhaps some movement relative to the separator anchorage, which would contribute to the same effect

The remedy is to shorten the nipple above the expansion joint until this joint is as close to the tee as possible. This will decrease the amount of movement to take up.

G. M. WESLEY.

LaFayette, Ind.

In reply to Mr. Blessing's question in the Feb. 13 issue, I think the trouble is due either to crystallization because of vibration or more probably to unequal expansion, as the cylinder is steam-jacketed, although there is an expansion joint provided.

If the flanges of the side-pipe ells are not male and female, I believe that the trouble could be stopped by making the bolt holes a little larger and not do the final tightening up until the joint had "found its self." If it is a male and female joint, the tongue will probably have to be relieved a bit.

EDWARD H. LANE.

Kansas City, Mo.

Reduced Angular Advance

Referring to George Dreyer's letter under the above title in the issue of Jan. 23, I would say that it seems quite natural that a reduction of the angular advance would result in smoother running. Before the reduction was made the full pressure of the steam was exerted against the piston before it had reversed the direction of its travel. Consequently, even the slightest lost motion or looseness anywhere was bound to cause a noticeable pound.

When the change had been made the full steam pressure against the piston was not developed until the reverse stroke had been fairly started, as indicated by the slanting admission line. Hence the extreme reaction of the steam pressure and the momentum of the flywheel and moving parts were eliminated.

J. W. DICKSON.

Memphis, Tenn.

Cure for Hot Bearing

Referring to the practice mentioned by F. P. Strachan in the Feb. 13 issue of filing flats on a journal to cure a hot bearing, I have tried it on two very obstinate cases with perfect success.

I was having all kinds of trouble with the outboard bearing of a side-crank engine; the babbitt at some time had been heated and squashed out enough to let the shaft down about ¼ in. When I took the job, the shaft was level, but there was a ¼-in. shim under the bearing, and a quarter-inch space between the journal and the top cap. The journal was 9 in. in diameter and the babbitt metal hugged it closely for 180 deg. of the circle, if not more, and it seemed hopeless to get any lubricant between them. I chipped and filed one flat place

on the shaft, taking care of the chips and filings, to keep them out of the bearing. My idea of the flat was that it would catch some of the oil at each revolution, and carry it down to the place where it was needed.

I have recently tried the same cure in a very similar case, and with the same success, but I do not think much of the idea as applied to new machinery.

B. COPPING.

Oliver Springs, Tenn.

In the issue of Feb. 13, F. P. Strachan gives an unique way of curing a hot bearing and asks why it should not be adopted. If main-shaft journals of large engines were scored in this manner I would consider it poor practice, because the flat places would be hard on the babbitt and it would probably be necessary to rebabbitt the bearing twice as often as if the journal were perfect. The flat places would increase the pressure per square inch on the babbitt touched by the other places on the shaft.

The flat spots on the shaft would also tend to fill the oil with small particles of babbitt which would mean frequently renewing the oil in the oiling system. Taking it all together, I cannot see that flat spots would be of any advantage.

Good oil grooves cut in the babbitt would be a great deal better. A continuous oiling system with the bearings flooded with oil would go a long way toward preventing any hot bearing.

A. RAUCH.

Swissvale, Penn.

A Plant the Central Station Did Not Get

In the Feb. 13 issue it was told editorially how the central station got one plant. The following tells of one plant the central station did not get.

It is one of the large modern office-building installations of about 4000 hp. Hundreds of motors are used throughout the plant, and there are upward of 25 first-class passenger elevators—a veritable eyesore to the central-station solicitors. These people were covetous of this possible plum, and dreamed of one day ousting the old force and equipment and installing central-station service.

The company was going to build, and, of course, more power would be required, and the psychological moment had arrived for the central station to make its supreme effort. Many thousands of dollars worth of business depended upon it.

The chief is an ordinary everyday engineer, just like thousands of others who work in large cities but—he was not, like many, allowing his ego to get the upper hand of his better judgment; he was conscious of his eager competitors, and he knew that some day they would force him to render an account of his stewardship before a disinterested tribunal whose verdict would mean either his downfall or his permanency. And now that day had come.

A thorough, elaborate test of every piece of power-generating and power-consuming apparatus in the plant was begun. Days were spent in preparing for it; many more in conducting it, and finally the test was ended.

In his report to the board of directors the reputable engineer who conducted the test gave the facts as he found them. So favorable were they to the administration of the chief that a representative of the central station who was present was astounded by what he heard and exclaimed: "Why, our plant could not do as well!"

The engineer told him that if it could not, it had better get men that could. They did, but it was then too late to pluck the now harvested plum.

Efficiency accomplished it all. Be efficient and endure.

B. H. CHESTER.

Harrison, N. J.

Comparative Efficiency of Boilers

Supplementing the answer to the question under the above title in the Feb. 13 issue, I wish to point out that the water-tube boiler has these points in its favor.

1. Higher working pressure.
2. Larger capacity in a single unit.
3. Less floor space per horsepower installed.
4. Freer from disastrous explosions.
5. More accessible for cleaning.

To prove that the water-tube boiler is more efficient than the return-tubular boiler by submitting copies of tests would be impossible, for there are very few tests which are reliable. I believe, however, that there are other considerations to be given to this question and if accurate tests could be produced, the higher efficiency of the water-tube type could be shown. All boilers for power-plant use are built of plate and tubes of practically the same thicknesses, and having the same properties of heat conductivity, therefore, based on this consideration only, one boiler would be just as efficient as another.

Units fulfilling the following qualifications are more efficient than other types:

1. Best arrangement of the heating surface.
2. Best arrangement for baffling the gases.
3. Closest confinement of the gases to the heating surface throughout their travel.
4. Definite circulation.
5. Rapid circulation.
6. Best position of each individual section of the heating surface in its relation to contact with the hot gases, the accumulation of soot and scale.
7. Least restricted areas for the circulation of water, steam, or both at any point.
8. Gas passages of either fixed cross-sectional area or uniformly diminishing with the reduction of the volume of the gases due to decrease in temperature.
9. Fewest possible turns in gas passages to prevent increase in drop in draft.
10. Construction of baffles to entirely prevent short-circuiting of the gases.
11. Greatest possible steam area at point of liberation of steam from the heating surface to steam space.
12. Greatest possible practical distance between water level and steam outlet.
13. Steam space surrounded by hot gases.
14. Ample steam storage capacity to prevent any tendency toward lifting of the water by steam leaving the boiler.

A boiler must be kept clean to be efficient; therefore,

15. Fewest necessary parts to be removed to gain complete accessibility to all parts for cleaning.
16. Cost of cleaning as to time, labor, etc., to ward off carelessness and neglect of this operation.

Relation of setting to boiler efficiency:

17. Setting should be air-tight.
18. Setting should have proper thickness of walls with air spaces or material forming dead-air cells to prevent radiation.

The type of boiler having the greatest number of these advantages in its construction is best qualified for making and delivering dry steam; therefore, it should be the most efficient.

B. LEWIS.

New York City.

Lubricator Experience

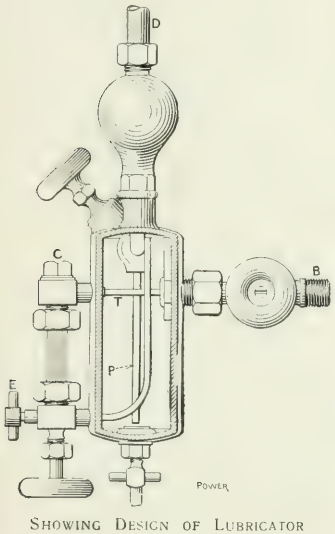
Mr. Watson's lubricator troubles described in the Feb. 6 issue recall some of the difficulties I have had with the different makes of lubricator. It is certain that a lubricator will not work unless the mechanical conditions are right.

Mr. Watson's cut of a lubricator, here reproduced, very fairly represents the average construction, but to force oil out through pipe *B* there must be a greater pressure on the oil in the body of the lubricator than that which is exerted by the steam against the oil at the end of pipe *B* in the steam pipe of the engine or pump. This is brought about by the weight of the oil in the lubricator, the weight of the column of condenser water in pipe *P* and the condenser and pipe *D*.

There is no established length for a condenser pipe for the different sizes of lubricators. It is frequently said that it could be too long or too short, and

some contend the longer the pipe the better the lubricator will feed; still others, that if it is too long there will be great liability of the oil being chilled, causing it to coagulate and thereby stop up the feed glass. If it is too short it will keep the oil too warm, cause it to feed too rapidly and smear up the feed glass.

My conclusions are that when a lubricator does not work there is either something wrong with the way it is connected up; something wrong mechanically or out of balance in some way, or the oil is bad. I have many times had just such troubles as Mr. Watson mentions and I find it is poor policy to be continually blowing out the feed glass by means of drip cock *E*. One will break many glasses, especially if the weather is cold and the lubricator is in an exposed position. If the feed glass continues to clog up, first shut off all valves on the lubricator, remove plug *C*, blow back gently



SHOWING DESIGN OF LUBRICATOR

through valve *B* and thereby clean out pipe *T*. Then put a soft rag or piece of cotton waste on a small stick and thoroughly swab out the feed glass. Next, take a tin of water of about the temperature of the water ordinarily in the feed glass to avoid cracking it and refill it, replace plug *C* and open the other valves; then the lubricator should get busy at once. If it does not, shut off everything again, remove plug *C* and drop in a few grains of salt. Salt water has a greater specific gravity than condensed water and it is therefore easy to see why oil, which is naturally lighter than water, will rise more readily through it.

Try to have the lubricator so piped and located that while working its temperature will never be so high or so low that one cannot bear a hand on the condenser without experiencing an unpleasant sensation. When draining be sure to get the water all out, and when starting, open all valves slowly.

THOMAS M. STERLING.

Middlebranch, Ohio.

I differ with Mr. Watson in his letter under the above heading, in the Feb. 6 number, as to blowing out the sight-feed glass. Many engineers blow out the water with steam and thereby heat the lubricator and cause it to be hard to start. Blowing out the sight-feed glass once in three months is often enough if the oil is kept clean. When I refill a lubricator I close the sight-feed valve and the steam valve and open the drip at the bottom, then take out the filling plug and pour oil in the plug opening. By the time the water is out the lubricator is filled and will start to work at once.

When the oil backs down in the feed glass I carefully regulate the feed and let it work empty in the usual way, for the feed is working the same as before, although the drops cannot be seen.

When the lubricator becomes empty the water works through the sight-feed valve and displaces the oil, and it runs through the tailpiece to the engine. When the oil is displaced by water in the sight-feed glass I close the valve and refill the same as above explained.

CHARLES BRACKEN.

Dunlo, Penn.

Noisy Heater

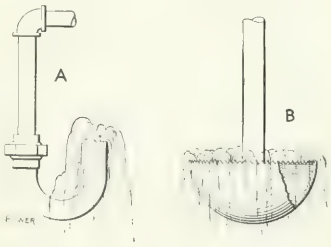
I think that L. C. Greene's trouble with a noisy heater, as related in the Feb. 6 issue, lies in the overflow pan, judging from my experience.

The heater of which I speak was noisy at times, especially when using the most water. Every time the heater was opened I would find that the overflow pan had jumped off of its supports. This pan fitted very close to the top of the heater, thus leaving a very small steam space between the top of the heater and the surface of the water in the pan. This had a tendency to produce water-hammer, causing the pan to lift off of its supports and kick over out of place. All that kept it from falling out was the extension of the water pipe into the pan. The trouble was cured by cutting down the sides of the pan 1½ in.

E. G. HOPPE.

Cairo, Ill.

Referring to L. C. Greene's heater, described in the Feb. 6 issue, I think that the noise is caused by the cold inlet water condensing the vapor in the top of the heater. He does not show by sketch the arrangement of the heater, but I have always found that if cold water is admitted to any steam space by a pipe projecting downward into it, the noise will be caused in the pipe. It may be overcome by sealing the end of the pipe with



SHOWING MANNER OF WATER SEALING PIPE OUTLET

water, as shown at *A* or *B* in the accompanying figure. This is done in many types of heater.

W. T. MEINZER.

Brooklyn, N. Y.

Firebrick Furnace Arches

In Mr. Dixon's article under the above caption, in the Feb. 20 issue, a table was inadvertently given, the figures of which corresponded with the rise per foot of radius. Although this might be used in some cases, it is not nearly as useful as the accompanying table which is the one that should have been included in the article.—EDITOR.

Inches Rise per Foot of Span	Arc	Inches Rise per Foot of Span	Arc
⅛	23° 45′	1 1/16	67° 15′
1/16	26° 10′	1⅛	69° 30′
⅛	28° 30′	1 3/16	71° 40′
3/16	30° 50′	1¼	73° 45′
¼	33° 05′	1 5/16	75° 50′
5/16	35° 30′	1⅜	78° 00′
⅜	37° 50′	1 7/16	80° 10′
7/16	40° 10′	1½	82° 15′
½	42° 25′	1 9/16	84° 20′
9/16	44° 45′	1⅝	86° 25′
⅝	47° 5′	1 11/16	88° 10′
11/16	49° 20′	1¾	90° 30′
¾	51° 40′	1 13/16	92° 30′
13/16	53° 55′	1⅞	94° 15′
⅞	56° 10′	1 15/16	96° 30′
15/16	58° 25′	2	98° 30′
1	60° 15′	2 1/16	100° 30′
1 1/16	62° 50′	2⅛	102° 30′
1⅛	65° 05′	2 3/16	104° 20′

License Laws

Referring to the recent discussion under the above heading, Mr. Hawkins need not go to Massachusetts to find the kind of examination he desires; Baltimore is nearer for him.

Here we have examinations which embrace such matters as valve setting on slide-valve, automatic and Corliss engines, principles of operation of various types of governor, indicator diagrams, bracing boilers, safety-valve rules, safe working pressures, horsepower of engines and boilers, boiler efficiency, safe speeds of flywheels, refrigeration, hydraulic elevators, installation and care of piping, etc.

M. N. STEVENS.

Baltimore, Md.

Death of Rear Admiral Melville

Rear Admiral George Wallace Melville, U. S. N., retired, noted as an engineer and explorer, died at his home in Philadelphia on Mar. 17 from paralysis.

Born in New York, Jan. 10, 1841, he was descended from a distinguished Scotch family which figured prominently during the reign of Henry VIII. He was educated at the Brooklyn Polytechnic Institute and later entered as an apprentice in the engineering works of James Binns, in Brooklyn, where he received his practical training.

At the outbreak of the Civil War, he entered the navy as third-assistant engineer and served on board the "Michigan," the "Dakota" and other vessels, and took part in several engagements, including the capture of Norfolk. Shortly after this, however, he contracted typhoid fever and was sent to the hospital at Key West.

In 1864, the "Wachusett," to which he was attached, was lying in the port of Bahia, Brazil, near the Confederate ship "Florida" and at a council held in the cabin it was proposed to ram the latter vessel, but an objection was raised on the ground that the shock would loosen the boilers, break the steam-pipe joints and scald everybody below on the "Wachusett." Melville met this objection by the quiet proposition to stay below alone and take his chances, and the scheme was adopted. In the attack, a cable jammed and an ineffective blow was struck, but the "Florida" was otherwise captured and Melville was put on board of her to act as chief engineer.

After a period of several years spent on various ships of the navy, Melville became associated with a series of arctic relief expeditions which were destined to make him an international figure.

The "Jeanette" expedition through Bering Straits was equipped for the government in 1879 with funds supplied chiefly by James Gordon Bennett, of the *New York Herald*. Lieutenant De Long was selected to command the expedition and Melville was chosen as chief engineer. From the start at San Francisco, Melville seems to have been the main reliance of De Long, whose reports redound with his praise, and are so much occupied with his mechanical contrivances that, as the commander himself remarked, "they look more like an engineer's notebook than a seaman's log."

The necessity for constant pumping to keep down a bad leak encountered in the ice pack led Melville to contrive all sorts of devices for saving coal, culminating in a pump and windmill of his own manufacture. His courage and cheerfulness never faltered, and he kept up the spirits of the others.

Soon after passing through Bering Straits, the "Jeanette" was caught in the ice pack, where she was held for nearly two years, drifting 500 miles to the northwest. On June 11, 1881, the "Jeanette" sank, her crew being forced to escape on foot over the ice toward the Siberian coast, a distance of 500 miles, the nearest intervening island being 150 miles away.

Rear-Admiral George Wallace Melville, U. S. N., Retired

After two weeks, De Long observed that the drifting of the fields had carried them 21 miles farther north than at the start, but by August they arrived within 90 miles of the mainland, a journey across open water being possible the rest of the way. De Long had distributed the party in three boats, taking charge of the first one himself and placing the others under command of Lieut. Chipp and Melville respectively.

A storm arose and Chipp's boat foundered, De Long's and Melville's being separated. The latter reached land and after excessive hardships found a settlement of the Yakut Eskimos from whom he received succor. The party had frozen hands and feet, Melville himself for 15 days being unable to stand. As soon as possible, he proceeded south to a Russian outpost, but instead of returning to civilization, he immediately collected such supplies as northern Siberia afforded and turned back into the winter night to search for De Long's party, two scouts from which had met him. His only companions were two Yakuts. The windings of the retreat from the "Jeanette" had aggregated 2200 miles; now, with hardly any intervening rest, Melville's devotion to duty led him 1100 miles more and this under conditions of season and preparation which rendered his exploits practically unprecedented. He found traces of De Long, but lost the trail and thus was compelled to return.

Even this was not the end of his efforts, for January found him northward bound again, with better equipment. At last he discovered the corpses of De Long and others and buried them on a high point of land, building over their graves a cairn with a timber cross, which tomb has been reproduced in granite and marble at Annapolis, where the bodies now repose.

But still another Arctic voyage lay before Melville. Lieut. A. W. Greely, U. S. A., with a party of 25, had been sent in 1881 to establish a meteorological station at Lady Franklin Bay in the Greenland region. Being cut off from supplies and not having been heard from, a relief expedition was sent to their aid in the winter of 1883-84.

In the equipment of this expedition, much dependence was placed upon Melville's advice. He went along as chief engineer of the "Thetis," flagship of Commander (later Rear Admiral) W. S. Schley, who subsequently came into fame at the battle of Santiago. The starving survivors of the Greely party were finally found near Cape Sabine, in Ellesmere Land. For his gallant work in connection with this expedition he was awarded a gold medal by Congress and was advanced 15 numbers in rank, soon being detailed as chief engineer of the navy.

Admiral Melville did not tarry about making much innovations in naval design as his good judgment dictated. One of the first was to get rid of the notion that engines must be horizontal, so that they could be stowed down in the hold where nobody wanted to put anything else. His initial venture with vertical engines was upon the "Maine."

About the beginning of Melville's term, the recent resumption of the use of forced draft had brought about a craze all over the world for reducing boiler weight to the last degree, and the talented Sennett, the British engineer-in-chief, ruined his reputation by the effort to get a horsepower on less than 1.5 sq.ft. of heating surface. At first there was nothing but praise for him, but when one ship after another proved a failure, it was found that he had been reckless. Melville refused absolutely to go to such lengths, his favorite expression being, "I never send a boy to do a man's work." While the English ships were being pulled through at reduced power by the Admiralty ferrule, the United States ships went along without a single failure or mishap and the rest of the world found that Melville, while as bold as the boldest, would not sacrifice sound engineering to popular clamor. He was conservative in his progressiveness.

He was the first engineer-in-chief of any navy to come out distinctly and strongly as an advocate of water-tube boilers for large vessels and, moreover, was the first naval engineer to secure accurate data upon the coal consumption in forced-draft trials. He also introduced the standardized screw as a method of determining speed trials, and credit is due to him for the first series of experimental data on the use of steam jets for forced draft.

One of Melville's greatest successes early in the building of the new navy was the 20,000-hp. cruiser "Columbia," built in 1890. In her construction, Admiral Melville, against the urgent advice of friends, risked his professional reputation to provide triple screws. When designed, this ship had larger machinery than that of any afloat. She crossed the ocean from Southampton to Sandy Hook in less than seven days, greatly reducing the existing warship records for a transatlantic passage and beating, by at least a day, the expectations of her designer and builder. Even this speed record was soon broken by her sister ship the "Minneapolis."

Foreign nations, England not included, followed the lead and made extensive use of triple screws, but for some reason which has never been explained, the admiral's desire to continue the policy of putting them in was negatived by the Navy Department.

How far Melville was ahead of the general naval mind, can be inferred from his suggestion of a ship of the "Dreadnought" type as long ago as 1899. Furthermore, his resourcefulness was exhibited during the war with Spain in the construction of a repair ship and a water-distilling ship.

One of the remarkable characteristics of Admiral Melville, which enabled him to perform such an immense amount of work, was his quality of inspiring admiration, respect and loyalty in his subordinates.

Under the rule of retirement at 62 years of age, he passed out of office in August, 1903, at the end of his third term and sixteenth year as engineer-in-chief of the navy. So long a tenure of office by a bureau chief was probably unprecedented in the navy. He was then as active, mentally and physically, as most men are at fifty.

Admiral Melville later resided in Philadelphia, which had been his home before his service in Washington, and was the recipient of distinguished professional honor. In 1896 he received from Stevens Institute of Technology the degree of doctor of engineering, an honor which is rarely granted by that institution. Among other degrees awarded him was LL.D. His bust in bronze adorns the War Museum of the Loyal Legion in Philadelphia.

As president of the American Society of Mechanical Engineers, he had already served the term of 1898-1899, and when the society met in Washington in May, 1909, a session was spent in witnessing the presentation of his portrait, painted by Ivanowski, to the National Gallery.

Convention, American Boiler Manufacturers' Association

The twenty-fourth annual convention of the above association was called to order on Tuesday forenoon, Mar. 12, at the St. Charles Hotel, New Orleans, by the secretary, J. D. Farasey, and was welcomed to the city by Mayor Behrman. In the absence of the president, Col. E. D. Meier, W. H. Bateman responded in behalf of the association. J. Don Smith, of Charleston, second vice-president, then introduced John A. Murphy, of New Orleans, who, as a local member of the association, seconded the welcome of the mayor. While he was speaking, President Meier, whose train had been delayed, came in, and received a rousing welcome. J. W. Porch, president of the Progressive Union, was introduced and told of the work of the city in conserving to the people the river front, the building of a municipal belt line, water-works sewage plant, etc.

During the afternoon session D. J. Champion, of Cleveland, presented a paper upon "Rivets." Twenty years ago steel was regarded as a hard brittle metal adapted for the making of razors, etc. The openhearth basic process had made possible the production of steel which was better than iron for most of the uses for which that metal had been employed. In addition to high tensile strength it possessed great ductility, but it is not fibrous as is iron, and should not be subjected in the form of rivets to the nicking and bending test.

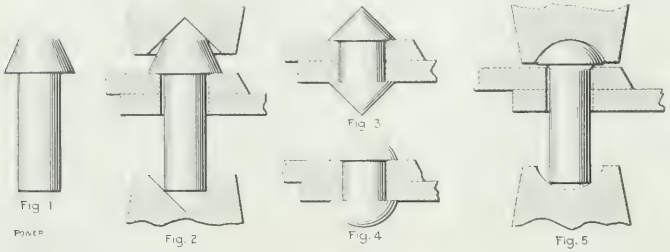
Mr. Champion's paper brought out an unlisted paper or discussion by H. J. Hartley, of the Cramp Ship Building Co., of Philadelphia, on "Hydraulic Riveting." His remarks dealt with the subject of hydraulic pressures as applied to riveting, on which there appears to be considerable diversity of opinion. In a number of tests made by William Sellers & Co. the data pointed to a pressure of 300,000 lb. per square inch of rivet section for driving and heading cold rivets. At the Baldwin Locomotive Works a series of tests for determining the best pressures for driving rivets in high-pressure steam boilers gave an average result of 160,000 lb. per square inch of rivet section. Mr. Hartley emphasized the importance of the increased pressure at the terminal stroke of the ram due to the surge of the accumulator at the end of the stroke. The increase runs as high as 60 per cent. and its effect in filling the rivet hole and making tight work is much the same as a second pressure of the rivet after it is partially cooled. In the course of his talk the speaker displayed a number of blueprints showing the shapes of rivet heads in common use. These are reproduced in the accompanying illustrations.

Fig. 1 shows the shape of rivet head mostly used by manufacturers. Fig. 2

shows a rivet with a pan-shaped head, ready to be driven with cone-shaped dies; the rivet being hot and the initial pressure bearing on the head and point, it necessarily follows that the rivet must flow into the dies before it gets bearing sufficient to squeeze it into the dies.

Fig. 3 represents the shape of the rivet head after being driven.

Fig. 5 shows a rivet with a round-shaped head, with a fillet under the head, heated and ready to be driven. It may be noticed that the dies on the head and point bear more centrally, and while the



die at the blank end of the rivet has a slight point bearing like Fig. 2, yet it is so little, due to the head end being solidly and firmly held in the die, that it may be said the initial pressure is bearing centrally on both ends of the rivet, thus permitting the rivet to flow into the hole while filling the radial-shaped dies. In other words, the main feature is accomplished by the rivet filling the hole before the head is formed.

Fig. 4 is a sketch of a rivet driven with a round-shaped die.

The round head is the better and also stronger in the shearing section of the head. It is also much easier to calk a round-head than a cone-head rivet, if such should ever be required. The first indentation of the calking tool on a round-head rivet forms an arch or backing to the tool, which has the effect of forcing the metal down to the plate, similar to calking the edge of a seam, while the same operation on a pan- and cone-shaped head has a tendency to curl up the thin edges of the rivet on account of insufficient metal above the calking surface.

On Wednesday morning the first order of business was to report Cleveland as the convention city for 1913, when the silver anniversary of the association will be celebrated. All the officers of the previous year were reëlected, as were also those of the supplymen with the exception of T. P. Wallace, of the executive committee, who is now replacing W. L. Hirsch, of Pittsburg. The convention was then ready for the papers scheduled for the day.

In the absence of H. A. Beale, Jr., George Thomas, of the Parkesburg Iron Co., presented a paper on the "History of Charcoal Iron and the Manufacture of Charcoal Iron Boiler Tubes." He took up the earlier methods of production direct from the ore and then dwelt at some length upon the present practice in this country of making charcoal iron from wrought and steel scrap. In this process the forge fire is run with a cold blast and one tuyere is used, the cold blast producing a better quality of iron and the one tuyere making it possible for the forgeman to give closer attention to the mixture.

He stated that the principal use of charcoal iron in America is for iron roofing and boiler tubes, the advantages possessed for the latter service being that it will not crystallize under shock, that it is ductile, is noncorrosive and will not pit. In explanation of its noncorrosive qualities two theories were advanced: one, that the intimately mixed network of cinder forms a protective covering; and another, that its homogeneous nature, purity and low percentage of manganese prevent electrolysis.

The paper of J. J. Dunn, of the Shelby Steel Tube Co., dealt with the manufacture of seamless steel boiler tubes and proved especially instructive. Mr. Dunn showed how the development in steam engineering had progressed hand in hand with the processes in manufacturing steel, dependent, of course, upon the ability of the material to withstand the steam pressures used. He then described and illustrated the method of manufacturing seamless steel tubing by the piercing and cold-drawn processes and gave comparative figures relating to the strength and ductility of hot- and cold-drawn tubing.

The use of compressed air in boiler shops was taken up somewhat in detail by Thomas Aldcorn, of New York. Basing his argument upon the contention that the generating plant, of which the compressor is an important element, is really the heart of the whole establishment, Mr. Aldcorn proceeded to give some pointers on compressors. In this connection he recommended the pressures to be employed and under what conditions single and compound compressors should be used. Regarding the use of pneumatically operated tools he showed how not only was the speed increased but also that the quality of work was improved with air-driven riveting machines, hammers, drills, etc., as compared to similar tools when operated by hand.

H. C. Meinholtz, of St. Louis, Mo., gave an instructive paper upon the modern boiler shop, taking up the location, construction, general arrangement and equipment.

"Boiler Explosions, Their Causes and Prevention" was the subject of a paper by S. F. Jeter, of the Hartford Steam Boiler Insurance Inspection Co. An abstract is presented on pages 426 and 427 of this issue.

A Group at the New Orleans Convention

Charles L. Huston, vice-president of the Lukens Iron & Steel Co., discussed the segregation of carbon, phosphorus and sulphur during the process of cooling, thus producing steel of nonuniform quality and making a higher factor of safety necessary. This segregation, he attributed to two causes: first, the steadily accumulating wall of solidified steel at the outer portion near the mold con-

stantly expels into the liquid portion the hardening elements or metalloids, such as carbide of iron, etc.; second, there is a tendency for these metalloids to float toward the top by reason of the difference in specific gravity.

Closely related to this segregation is the formation of blow-holes due to the confined gases within the ingot. Experiments were quoted to show that if the metal is rolled hot, these holes will close up to a large extent, so as to produce a fairly solid plate, although their entire elimination is almost impossible.

Mr. Huston recommended a good soft steel of moderate tensile strength (about 55,000 lb. per square inch) rather than a steel of high tensile strength which is apt to be brittle. This point had recently been impressed upon the United States government officials and as a result they have consented to a reduction in the specifications from 75,000 to 65,000 lb. per square inch.

W. H. S. Bateman gave an interesting talk on the association in the old days, as it is at the present, and concluded with some suggestions for its betterment. It was his opinion that the society should be divided into five sections as follows: Marine boiler; water-tube boiler; return-tubular boiler, including small type fire-box boilers; house heating, miscellaneous boilers and pressure tank builder's section, and locomotive boiler. Each section to have its own chairman and secretary and the larger sections, if necessary, to be subdivided and located in the various states, according to the number of shops within a certain territory. At the convention these sections could hold their own meetings and all could be arranged so as not to interfere with the general meeting of the association as a whole. The appointment of a committee to confer with the various state legislatures who are contemplating the introduction of state boiler rules and regulations was also recommended.

On Thursday the report of the Committee on Uniform Boiler Specifications was read and unanimously adopted. It called for several modifications in the Massachusetts laws, and as it was the most important feature of the entire convention, it will be printed in full in the next issue of POWER.

W. O. Hart, member from Louisiana of the National Commission for Uniform State Laws, appeared before the convention and told of the work of this commission, which includes accredited representatives from every state and territory except Alaska. They will meet at Milwaukee probably in August and would be glad to consider uniform boiler laws. His invitation to have a representative of the association present at the meeting was accepted.

The convention adjourned at noon on Thursday to assemble the same evening at the banquet at the St. Charles. About 125 sat at table, with Col. E. D. Meier officiating as toastmaster. An especially appreciated feature was the presentation on behalf of the supplymen's association by Thomas Aldcorn of a silver set of five pieces, to John Corbett, president of the Supplymen. All ladies were presented with a silver souvenir spoon of New Orleans make and emblematic of the city. The usual resolutions of thanks to the mayor, local committee and all who had contributed to the success of the meeting were passed, and the 1912 convention adjourned with a high appreciation of the hospitality and courtesy extended and the elaborate arrangements made for the entertainment of the ladies.

BOILER MANUFACTURERS' BANQUET AT THE ST. CHARLES HOTEL, NEW ORLEANS, LA.

First Steam Turbine Now a Monument

The General Electric Co. has reërected in the center of a park plot in its grounds at Schenectady, N. Y., the first 5000-kw. Curtis steam turbine installed in the Fisk St. station of the Commonwealth Edison Co. at Chicago. It is to serve as a memorial to the rapid development of the steam-turbine unit applied to central-station service.

This turbine was installed in the Fisk St. station eight years ago, being put in operation Oct. 2, 1903, and remained in continuous service until May 29, 1909. It was specified in the contract by President Insull when this unit was replaced that it should be set up as a monument to commemorate the great step in engineering which its installation marked. A bronze tablet detailing its history has been placed on the turbine

Boiler Explosion at Fluvanna

By the bursting of a boiler in the Smiley crating mill, on Mar. 11, at Fluvanna, Penn., the plant was completely wrecked and two men injured. It is thought that a frozen pipe indirectly caused the accident.

Locomotive Boiler Explosion

By the explosion of a Southern Pacific locomotive in this road's roundhouse at San Antonio, Tex., on Mar. 18, it is reported by the daily press, 32 strike breakers were killed and 60 were badly injured. No further details could be had at the time of going to press. There is a strong rumor that the explosion was caused by a charge of nitroglycerin.

Newark Industrial Exposition

Elaborate preparations are being made for the industrial exposition to be held in Newark, N. J., May 13 to 25.

It is claimed that 100,000 different articles are manufactured in the 3000 shops of the Newark industrial district. Not only will the products of Newark's factories be shown, but also the processes of manufacture. There will be many special features of an entertaining and educational nature, including a series of lectures on the industrial development and opportunities of Greater Newark.

The committees in charge number 300 representative citizens of the Newark industrial district, including Chairman Curtis R. Burnett, president of the Board of Trade; Thomas A. Edison, ex-Governor Franklin Murphy, Forrest F. Dryden, president of the Prudential Insurance Co.; Frederick Frelinghuysen, president of the Mutual Benefit Life Insurance Co.; Hon. Thomas N. McCarter, president of the Public Service Corporation of Newark.

No Water Power Trust on Government Territory

On Mar. 13, at Washington, the House, by a vote of 98 to 37, defeated a measure permitting the Hydro-Electric Co. to lay a pipe line across part of the Mono National Forest Reservation in California.

It was charged that the "water-power trust" had sought to influence the legislators and several members claimed that they had been victims of a lobby.

Representative C. D. Smith, of New York, has introduced a bill to compel every "counsel or agent" of corporations or individuals seeking Congress legislation to register with both houses on Dec. 1 of each year, with heavy fine and imprisonment as penalty for failure to comply. His bill would compel corporations and others who employ lobbyists to file with the Senate and House two months after the close of each session of Congress a detailed statement of expenses.

CORRECTION: In the tabulation of power-plant equipment of the Hazard Manufacturing Co.'s new power plant, published in the Mar. 12 issue, the pumps were said to be manufactured by the Nelson-Snyder Manufacturing Co.; the firm name is, of course, Wilson-Snyder.

A Million Dollar Plant for Savannah

A power plant of 11,000 kw. capacity and costing $1,000,000 will be built on the Savannah River by the Savannah Electric Co.

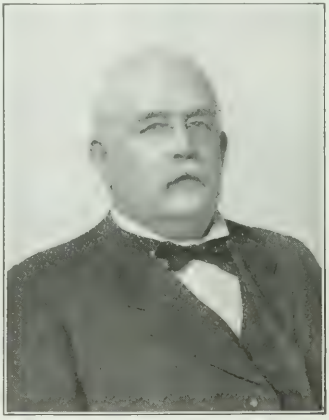
Work will begin at once and it is stated that the plant will be completed by Nov. 1. The company has been given options on three plots of river property, but it has not been determined which will be purchased.

Coal Mined in 1910

The amount of coal mined in the United States in 1910, according to figures of the United States Geological Survey, was greater by 10,000,000 tons than the total tonnage which had been mined up to the close of the year 1871.

OBITUARY

Dr. Henry Wilson Spangler, Whitney Professor of Dynamical Engineering at the University of Pennsylvania, Philadelphia, Penn., died on Mar. 17, at his home in West Philadelphia.



PROF. HENRY W. SPANGLER

Dr. Spangler, who had been connected with the University of Pennsylvania for more than 20 years, was born in Carlisle, Penn., on Jan. 18, 1858. He was graduated from the United States Naval Academy in 1878 and was an engineer in the United States Navy from 1878 to 1889; and in 1898, during the Spanish-American War, he again served in the Navy for a short time.

He was called to the university in 1881 to take the chair of Assistant Professor of Mechanical Engineering, which position he held for three years and again for two years, from 1887 to 1889, when he became professor. Dr. Spangler was the head of the mechanical engineering department until his death and held the Whitney Professorship of Dynamical Engineering.

In 1896 the university conferred upon him the honorary degree of Master of Science and ten years later the degree of Doctor of Science.

He was a member of the Advisory Council of the Engineering Congress held in Chicago in 1893; a member of the Jury of Awards of the Buffalo Exposition in 1901, and a member of many scientific organizations, including the Franklin Institute, American Society of Mechanical Engineers, American Society of Naval Architects and Marine Engineers and the Engineers Club of Philadelphia, of which he was president in 1890 and again in 1908.

Doctor Spangler was the author of a number of standard works, among them one on "Valve Gears," "Notes on Thermodynamics," "Elements of Steam Engineering," and was the co-author of "Graphics."

SOCIETY NOTES

A lecture on "Steam Plant Management and Operation" will be given under the auspices of the general committee of the Combined Associations, N. A. S. E., of Manhattan and Bronx, by Prof. E. V. Lallier, M. E., at the Broadway Central Hotel, Broadway near Third St., on Wednesday evening, Apr. 3, at 8:15 p.m. This lecture will combine the four essential features of steam-plant operation, practical training, technical knowledge, coöperation and the physical condition of the plant. Members of all bodies of operating and mechanical engineers, owners of steam plants, real-estate agents and steam users are cordially invited to attend.

PERSONAL

H. R. Setz, chief engineer of the Struthers-Wells Co., of Warren, Penn., for the last two years, has just accepted the position of chief engineer with the Otto Gas Engine Works, of Philadelphia. Mr. Setz was formerly connected with several of the leading American and European gas- and oil-engine manufacturers. His particular attention will be directed toward the development of a complete line of horizontal Otto Diesel engines.

Albert E. Guy, for six years chief engineer of the De Laval Steam Turbine Co., Trenton, N. J., now occupies a similar position with the Wilson-Snyder Centrifugal Pump Co., of Pittsburg, Penn. This company, in connection with the Wilson-Snyder Manufacturing Co., has been organized to manufacture and sell complete new lines of high-grade centrifugal pumps of Mr. Guy's design. As many of our readers will remember, Mr. Guy has been a prominent contributor to POWER of technical articles.

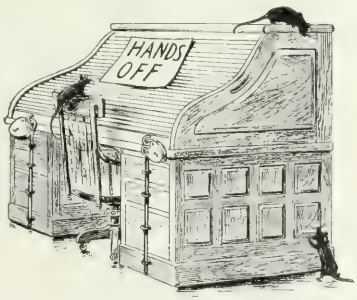
POWER

Vol. 35 NEW YORK, APRIL 2, 1912 No. 14

"A MAN cannot turn anything over in his mind unless he knows it."

How strongly this applies to the power plant, where men must not only know a thing but know it well. The efficiency of the plant depends upon that of each individual in it, and individual efficiency is dependent upon his knowledge of his work. Where such work is potent with danger, and pregnant with liabilities to costly accidents, the skill required to perform it must necessarily be high.

Skill is applied knowledge, and the broader the knowledge of the work to be done, the more skilled is the worker.



There are quite a few engineers who do not give their subordinates full access to the means of acquiring more definite knowledge of their particular duties; done intentionally, this is nothing short of criminal; if not, it is gross negligence, and cannot be justified by any process of reasoning.

It is not enough that a switchboard operator merely know the switches and instruments on the board; he should be thoroughly acquainted with the numerous circuits connected with it. If it is a remote-control, high-tension board, the reasons are multiplied because the complications are greater.

Such operators and the dynamo and motor tenders should be supplied with blueprints showing in detail the circuits of the board, machines, elevators and whatever other apparatus the plant maintains.

The steam-fitters and plumber should also be supplied with charts hung where they will facilitate locating the valves controlling the lines of the steam and water systems.

Such charts or prints fail of their purpose when locked in the drawer of the chief's desk. One might as well have a telephone without a directory.

Engineers should have ready access to duplicates of these charts that they may familiarize themselves with the locations to which the charts refer. When trouble arises is no time to gather information as to the remedy for the trouble; the men must know on the instant what to do, and how best to do it. The uses of such means of information is highly necessary if the chief would have his men become better acquainted with the plant.

While the chief is to blame for such conditions, the engineers and those doing other work about the plant are oftentimes equally at fault. They are often reluctant to correctly and thoroughly answer the questions of the firemen, oilers, wipers, etc., and they fail to demonstrate to them where possible.

Engineering is greater than the individual engaged in it, and it is this mutual aid which will make for the betterment of the vocation.

Winding Engines of the Ashley Planes

By Warren O. Rogers

There are three planes at Ashley, Penn., over which the freight cars handled by the Central R. R. of New Jersey are drawn up the mountain.

Each plane is equipped with a twin-winding engine and drives two winding drums over which a 2½-in. cable runs.

The ends of each cable are attached to a barney-car which pushes the loaded freight cars up the planes.

When going into Wilkes-Barre, Penn., from the east on the Lehigh Valley R.R., the traveler will see, as he looks down the mountain when about 16 miles from the station, two sets of planes; a third is invisible behind the hill. These are known as the "Ashley Planes," and for years it has been the practice of the Central R.R. of New Jersey to haul freight cars up these three planes to the top of the mountain.

Powerful Engines Required

The first impression received is that powerful engines must be used in hauling the loaded freight cars up these steep grades. Curiosity overcame the writer's inclination to take things easy last Thanksgiving Day, and armed with a camera, a street car for Ashley where the planes terminate was boarded. A ride of about 20 minutes and the bottom of No. 3 plane was reached. No. 2 plane is about half-way up the mountain and has the heaviest grade of the three, and No. 1 plane lies at the top of the mountain.

The original machinery installed at these planes served its purpose for years, but in 1902 the winding machinery of the three planes was, to a large extent, rebuilt by the Bethlehem Steel Co. In place of the ordinary cast-iron winding gears, cut gears were substituted. Later on it was found that the increased traffic on the planes demanded higher speed, and it was gradually increased until it had been doubled, and still the amount of freight to be handled increased.

New Engines Installed

The excessive loads under which the engines were forced to labor soon caused them to begin to break down, and the same company which had made the repairs in 1902 was given a contract to build engines of sufficient size to handle the freight traffic going up the planes. These engines were made chiefly of steel frames and the bedplates were so designed that they would fit on the old foundations and between the old winding drums. A special design of valve-gear was also placed on the engines. The throttle valve is operated by means of steam admitted to the valve piston, and the reversing gear is operated in the same manner. These arrangements call for very slight exertion on the part of the operator when handling the engine.

Winding Engine

In Fig. 1 is shown a view of the latest design of winding engine, which was made by the Bethlehem Steel Co. On the engine shaft is mounted a spur gear 70 in. in diameter which meshes with two 20-ft. 10-in. geared sheave wheels, in which there are four grooves for the winding rope. The two-segment spur gearwheel has 36 cut teeth with a pitch of 6⅛ in. The winding gearwheels are of the built-up type, the rims, segments, hub and spoke being bolted together by 1¾-in. bolts. The pinion is geared to a 70-in. crankshaft and each of the two winding wheels is mounted on a separate 19-in. shaft.

The gear rims of both the pinion and the winding wheels are bolted to the body of each gearwheel and thus facilitate the making of repairs in case of a breakdown.

The engines are of the twin vertical type and have cylinders 48 in. in diameter by 40 in. stroke; the piston rods are each 6 in. in diameter. Steam is admitted to the steam chest of each cylinder through a 15-in. steam pipe and is exhausted to the atmosphere through an 18-in. exhaust pipe.

The engines at Nos. 2 and 3 planes are practically of the same size and design as the new unit, except that the latter, which was built in 1909, has a different valve-gear, as shown in detail in Fig. 2.

The cables used in hauling the cars up the planes are wound around the winding wheels four times, and pass out of the engine room under the floor to the center of the double track, sheave wheels being used where the cables make a bend.

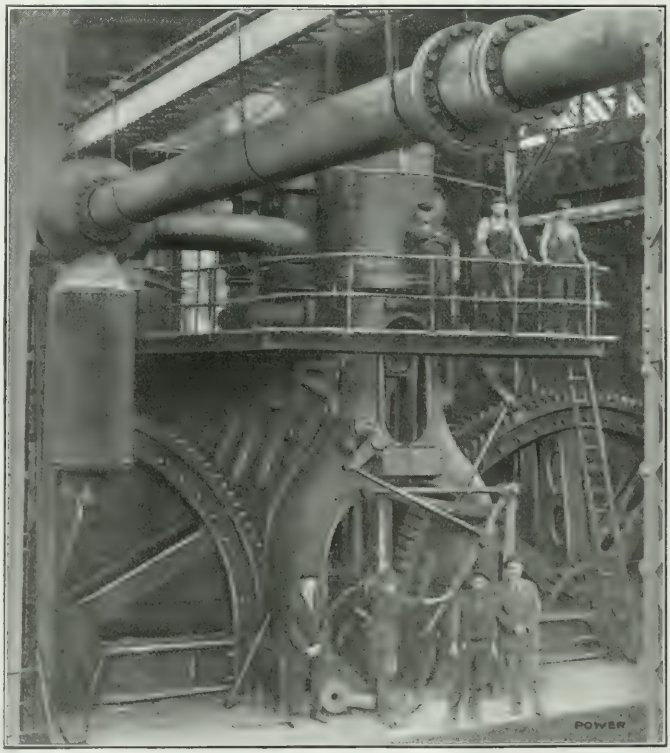


Fig. 1. The New Winding Engine at No. 1 Plane

No. 1 Plane

In Fig. 3 is shown, looking toward the bottom, a view of No. 1 plane. The barney car is on the down trip, and the method of taking care of the cable is also shown. In the pit between the rails there is one large sheave wheel about 4 ft. in diameter, and on either side of it there are small guide wheels about 8 in. in diameter.

The 2½-in. cable used on this plane is 4690 ft. in length, weighs 48,326 lb. and travels at a speed of 16 miles per hour. The time required to draw four 80-ton cars up No. 1 plane is 3½ min. The average tonnage of the rope is 10,000,000 tons. The ends of the haulage cable at each plane are secured to a barney car after the manner shown in Fig. 5.

Tail Rope

A 1½-in. tail rope is secured to the rear of each barney car having a tonnage twice that of the hauling cable, or 20,000,000. The tail rope runs on the same guide wheels that are used by the haulage rope. The slack is taken up by a compensating device, shown in Fig. 6. This consists of a sheave wheel mounted on a truck that is free to travel on a short incline track. The truck is weighted and as slack occurs in the tail cable from expansion or stretch, it is taken up by the compensating device.

No. 2 Plane

A view of No. 2 plane from the top is shown in Fig. 4. This plane has a grade of 14 per cent., and it requires 3 min. to draw three 80-ton gondola cars to the top at a speed of 20 miles an hour. The cable is 2¾ in. in diameter, is 3670 ft. long and weighs 44,512 lb. The hauling rope has a useful capacity of 630,000 tons

No. 3 Plane

The bottom, No. 3, plane has a grade of 5 per cent. and is equipped with a 2½-in. steel cable 5780 ft. in length. It weighs 59,792 lb. and runs at a speed of 13 miles per hour. The load on the plane is six 80-ton cars and is handled in 4½ min. Fig. 5 shows a train starting from the foot of No. 3 plane. The manner of handling the cars by means of a barney car is shown in Fig. 7.

The old barney cars were made of cast iron, but a new steel car has recently been built and a new motion of changing the gage of the wheels has been adopted. A new cable fastening has also been adopted, which makes it impossible for the rope to pull out of its fastening.

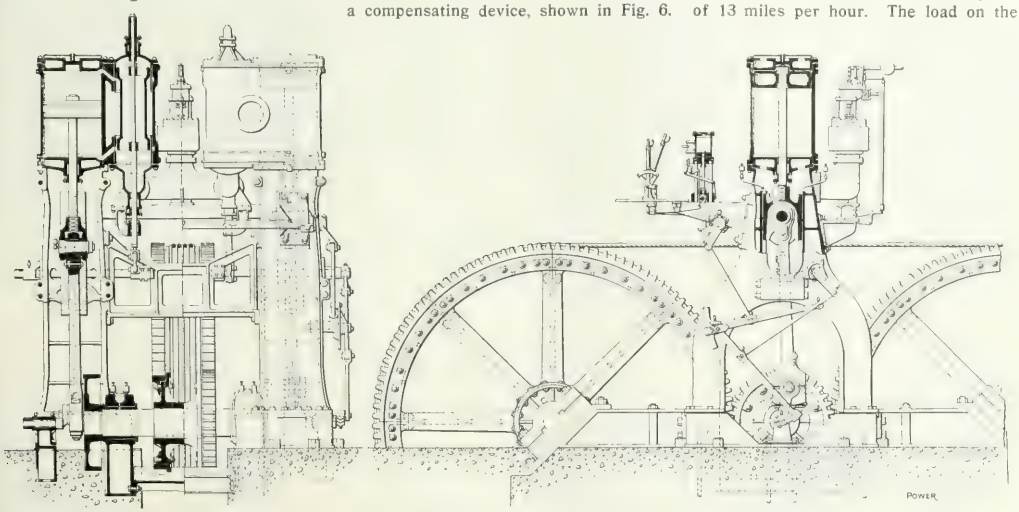


Fig. 2. Front and Side Elevation of Winding Engine at No. 1 Plane

Fig. 3. Looking Down No. 1 Plane

Fig. 4. Looking Down No. 2 Plane

Accidents Not Frequent

It is not often that an accident occurs, but when the cars do get away a genuine wreck follows. In Fig. 8 is

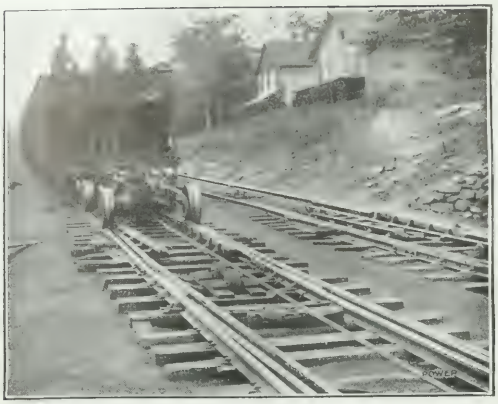


FIG. 5. BARNEY CAR ON NO. 1 PLANE; ALSO SWITCH ARRANGEMENT

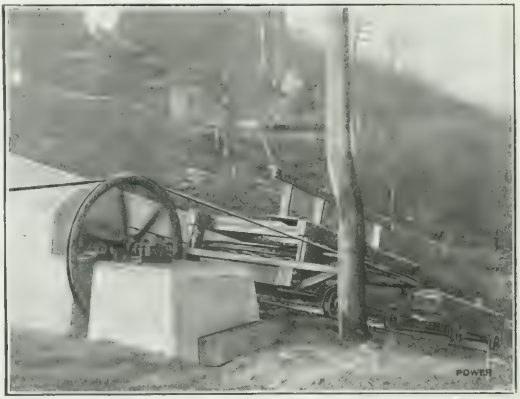


FIG. 6. HOW SLACK IN THE TALE ROPE IS TAKEN UP

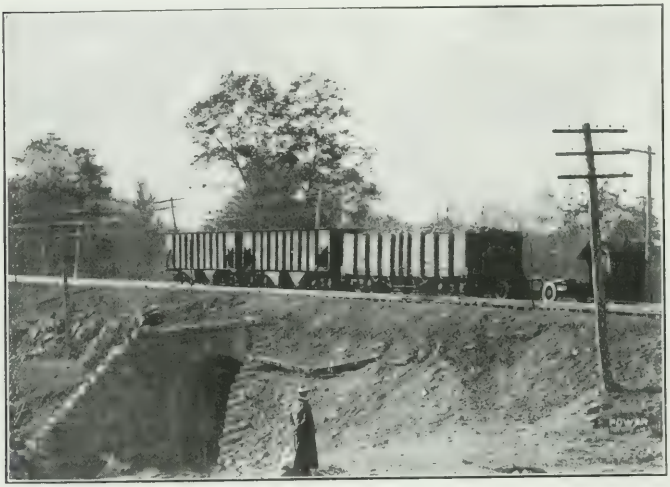


FIG. 7. BARNEY CAR AND LOADED COAL CARS ON NO. 2 PLANE

shown a spill which resulted from the cable pulling out of its fastenings on the barney car when the train of four loaded gondola coal cars was about halfway up No. 1 plane. Although the cars were wrecked, fortunately no one was hurt, owing, it is said, to the sprinting ability of the men who were employed at the foot of the plane.

AUTOMATIC SWITCHES

An examination of Fig. 5 shows an ingenious arrangement for automatically switching the barney car into the pit at the bottom of the plane. It will be noticed that, although the regular freight-car trucks are made with the wheel flanges on the inside of the rail, the barney car is made with the flanges on the outside of the rail.

Referring to the track construction in Fig. 5, it will be seen that there are three sets of rails on the near side of the barney car. The outside set is for the regular freight cars, but the four inside rails are for the barney car. In the illustration the barney car has just taken the wide-gage rails. If it were returning to the pit from which it has just emerged, the wheels, upon striking the turned-out end of the rails, would be forced closer to the body of the car and would travel on the inner rails, with the outside of the flange bearing against the inside of the outer rails.

When the wheels of the barney car strikes the point of the inside rails, the flanges strike the inside rails and are further forced toward the body of the car, taking the inside rails with the flanges bearing against the center rails. When the bottom of the pit is reached, the car runs through a spring switch onto the center rails, which rise abruptly to the track surface at the far end of the pit and run parallel with the outer rails until the frog is reached.

FIG. 8. RESULT OF A RUNAWAY

On the return trip, the car runs on the inner rails, but as it nears the point where the rails is turned out on the outside, the flanges of the barney-car wheels forces the rails out again and permits the tracks to assume their widest gage. As soon as the wheels have passed the points, the springs, which are in tension against the rails, force them back into place. The central rails are held in place by means of springs which force them against the outer rails. The barney car is made with four separate axles, each of which slides in a long square box, in the inner end of which is a spring which presses against the end of the axle.

An inner guide rail assists in forcing the outer rails apart as the barney-car wheel strikes them and the rails at the same time. Should the spring at the end of the axle break, the wheels would take the proper rails at the right place. The ordinary car trucks always take the outer rail.

Scale Prevention

By John Creen

For the treatment of moderate quantities of feed water in which carbonate of lime predominates, handy and effective apparatus may be contrived by the engineer out of one or more boiler tanks, in which the water is heated by exhaust steam through a system of pipe coils, soda or other chemicals being used as reagents. By this means very bad water may be purified of a large portion of its mineral matter, which is left behind in the tank. Feed-water heaters, whether using exhaust or live steam, answer the same purpose. In the lime process, 28 grains of caustic lime will give a total precipitate of 100 grains of carbonate, the 28 grains of caustic being themselves converted into 50 grains of carbonate.

But for various reasons, steam users often prefer to treat the water inside the boilers, in which case the use of caustic lime forms a too bulky precipitate, and some other reagent must therefore be employed. By using caustic soda, both carbonate and sulphate of lime can be thrown down, and the process is more rapid than with caustic lime and carbonate of soda. Suppose, for instance, a water contains 6 grains of carbonate, and 8.16 grains of sulphate of lime; by adding 3.75 grains of caustic soda to the water, these at once become 6.36 grains of carbonate of soda, and 6 grains of carbonate of lime are precipitated. The 6.36 grains of carbonate of soda decompose the 8.16 grains of sulphate of lime, and are converted into 8.52 grains of sulphate of soda, and another 6 grains of carbonate of lime are precipitated. Altogether, 12 grains of lime are thrown down, and the soda acts twice, first by absorbing an acid, and second by changing this acid for another. When used in this way, 31 grains of caustic soda will precipitate 100 grains of carbonate of lime. Soda therefore will remove nearly double the quantity removed by caustic lime from waters containing both carbonate and sulphate of lime, but the cost of treatment by soda is considerably more than by the lime treatment. The following formulas will be found useful:

1. Water in which carbonate of lime only is present—For treating 1000 gal. of water, 1060 grains of carbonate of soda, made caustic with 560 grains of burnt lime, are required for each grain of carbonate of lime per gallon. To produce the same result with soda, 1½ oz. of caustic soda for each grain of carbonate of lime present per gallon will be necessary for the treatment of 1000 gal.

2. Waters containing sulphate of lime only—For each grain of sulphate of lime per gallon, 1¾ oz. of pure carbonate of soda will be required to treat 1000 gal. of water.

3. When both carbonate and sulphate of lime are present—As explained for carbonate waters (1), 1½ oz. of caustic soda for each grain of carbonate of lime will precipitate the lime in 1000 gal., but this quantity will also throw down 1.36 grains of sulphate of lime at the same time, so that if the proportion of sulphate does not exceed the carbonate beyond the ratio of 8 to 6, the sulphate may be disregarded. If, however, sulphate of lime is present in a greater ratio, carbonate of soda should also be added. An excess of soda should be used to insure a proper reaction, which is greatly assisted by heating the water.

Unless the soda used is of the best quality and free from adulteration, leakages at the seams may be caused, or the plates and fittings may be attacked; the use of impure caustic soda has been the cause of much trouble in this direction.

When, however, scale has formed on the internal heating surfaces and shell of the boiler, there is an effective method (which the writer has practiced with success for many years) of removing it. Caustic potash answers this purpose, especially when the scale consists chiefly of mud, with sulphate and carbonate of lime and magnesia combined. Caustic potash is the concentrated lye sold in grocery stores, but if it is required in large quantities it should be purchased from wholesale druggists. Dissolve it in a barrel of water, say 40 lb. to the barrel, and then pump it into the boiler; this is about ⅛ lb. of potash per pound of water and is strong enough for the purpose.

The method employed by the writer was as follows: One boiler was cut out of service at noon on Saturday, the damper was nearly closed and the pressure let drop to 30 or 40 lb. The potash being ready, the mixture was pumped from a suitable tank into the boiler; continuing to pump clean water until the glass was full. The fire was then allowed to die out, and the boiler left in this condition for at least 24 hours, when the furnace was again lighted, and the steam pressure raised to 15 or 20 lb. The fire was then drawn and the boiler blown down; the bottom doors were taken off, all the chunks of scale which could not go through the blowoff cocks were removed, and the boiler was thoroughly washed out with water from a hose at high pressure. The boiler was then closed, filled with clean water and steam raised, and put into commission again. A repetition of this at every week-end for a few weeks will thoroughly clean the dirtiest boiler.

In handling caustic potash the utmost care must be used; it is truly caustic, and if a small portion splashes in one's face or eyes it will cause serious trouble. The same is true of the hands. For a very hard scale an acid purger should be used, as lime is alkaline and its antidote is an acid. Probably someone may exclaim loudly against using an acid purger, arguing that it will destroy the boiler. It is just here that trouble is likely to ensue in the hands of an inexperienced person. In the first place, an acid purger is largely diluted with water, and it attacks the scale first, having the greatest affinity for it. After that it would attack the boiler plates if allowed to remain in the boiler, but there can be no after effects of this character from a boiler purger, because it is no longer in the boiler when the scale is removed, the boiler cleaned out by hand, washed with a hose, filled up and blown out again before steam is raised. Of the two evils, it is best to choose the least, and in this case the use of a strong boiler purge is less than the injury and loss of fuel caused by scale.

Revenue in Public Water Power

A report of the new Conservation Commission recently submitted to the New York legislature finds that the waters of the state furnish a total flow having a capacity of 1,271,000 hp.

Ordinarily, development for manufacturing purposes is based upon an estimate of only 60 per cent. of the time of continuous flow. A well considered plan of conservation would yield an available horsepower of about 1,780,000. In an investigation before the foreign affairs committee of the House of Representatives it was shown that the Ontario Power Co., of Niagara, sells electric power for $9.40 per horsepower-year. At a rate of $30 for comparatively small developments it will be at once evident how large a source of income will be available to the state, whenever it develops its water powers.—*Scientific American.*

Cost of Isolated Plant Power

From a paper prepared by the American Engine Co., showing the cost of power as generated by noncondensing engines, the exhaust of which is used for heating during the winter season.

The method of arriving at the costs as herein outlined is applicable to any isolated plant.

Where steam heating is required, electric power may be generated as a by-product of the heating plant, at a cost of less than 2c. per kilowatt-hour in the majority of cases. The reasons for this low cost of generation may be summarized as follows:

First. The fixed costs, which go to make up a large share of the cost of power, are chargeable only against the additional investment for the plant by which electric power is generated, over and above the investment for the low-pressure steam-heating plant.

Second. The coal cost chargeable against electric power is reduced, during those periods when the exhaust steam is used for heating, to a small percentage of the coal consumed, represented by that part of the heat in the steam, which is lost between the high-pressure boiler and the heating system.

Third. The labor charge comprises only the additional labor required, as compared to a low-pressure heating plant. Furthermore, by reason of the additional labor, which is of a higher grade, greater economy is obtained in fuel consumption.

Fourth. While the charge for oil, waste, repairs and miscellaneous items is incurred entirely through the installation of the engine and generator, they amount to but a small proportion of the total expense.

Every isolated plant with exhaust-steam heating must be considered as a separate problem, because of the wide variation in load, cost of coal, water, labor, etc. The following case, which may be considered typical, will serve to outline the calculation whereby the cost of power may be determined, and secondly to indicate the influence on the cost per kilowatt-hour of the three most important factors, the fixed charges, the price of coal and the amount of exhaust steam used for heating.

Fixed Charges

An industrial plant operating 3000 hr. per year at an average load of 200 kw. will be assumed with two 100-kw. and one 50-kw. engine-driven dynamos installed. These, with suitable piping and auxiliaries, may be set down at $11,000.

Two 200-hp. boilers would be required. However, the total cost of these boilers would not be chargeable against power since boilers would also be required for the low-pressure heating plant. The cost per horsepower of low-pressure boilers, grates, stack, etc., is nearly the same as a similar high-pressure equipment. But as heat is lost and consumed between the high-pressure boiler and the heating system, a somewhat greater boiler capacity must be installed when power is to be generated. As the exhaust from an engine contains 80 to 90 per cent. of the heat given it, in the boiler, an increase in boiler capacity of 25 per cent. over the low-pressure equipment will easily take care of this item. Considering $18.75 per horsepower, including boiler, grates, stack setting, piping and labor of installation, the additional boiler cost would be

400 *hp.* × 20% × $18.75 = $1500

The two largest items of additional first cost, totaling $12,500, have been considered. It might, of course, be profitable to install other apparatus in a plant of this character, as, for instance, a feed-water heater. But as that apparatus should pay for itself out of the coal saved, it will not be considered under the items of additional first cost.

Of the total additional cost of $12,500, a certain fixed percentage must be charged off every year against the cost of power. The fixed charges would be:

	Per cent.
Interest at	5
Depreciation at	5
Insurance, real estate, upkeep, obsolescence	5
Total	15

And

$$0.15 \times \$12{,}500 = \$1875 \qquad (1)$$

the fixed charge per year against the additional investment for apparatus to generate power as a byproduct of the heating system.

Labor, Oil, Waste, Etc.

The cost for additional labor may be taken as one man at $800 per year, while repairs, oil waste, packing, etc., may be set down as $250, making a total of

$1050 (2)

Coal

The coal chargeable against power comprises the coal equivalent of the heat lost between the high-pressure boiler and the heating system when the heating season is on; and, when no heating is being done, all of the coal burned is chargeable against power.

The cost for coal will depend therefore upon (a) the steam consumption of the engines; (b) the evaporation of the boiler; (c) the cost of coal, and (d) the percentage of the total amount of steam generated which is used by the heating system.

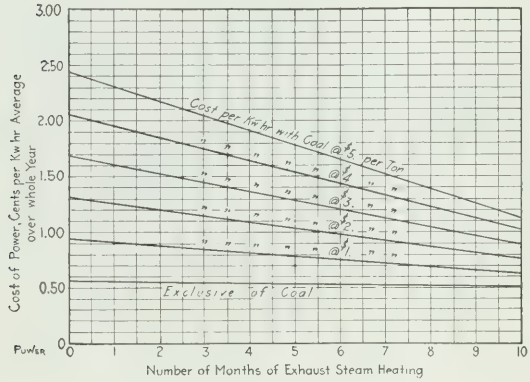

Cost of Power, Cents per Kw hr Average over whole Year
Cost per Kw hr with Coal @ $5 per Ton
Exclusive of Coal
Power
Number of Months of Exhaust Steam Heating

Fig. 1. Total Cost

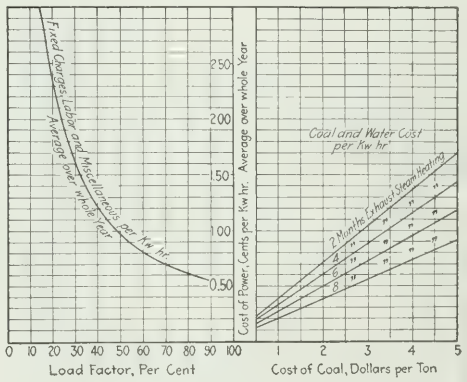

Fixed Charges, Labor and Miscellaneous per Kw hr Average over whole Year
Coal and Water Cost per Kw hr
7 Months Exhaust Steam Heating
Cost of Power, Cents per Kw hr Average over whole Year
Load Factor, Per Cent
Cost of Coal, Dollars per Ton

Fig. 2. Cost as Dependent upon Load Factor

(a) The steam consumption of a good high-speed engine for isolated-plant work is 26 lb. per horsepower-hour, running noncondensing, or 40 lb. per kilowatt-hour. To be on the safe side and to take care of the effect of reduced and fluctuating loads on the steam consumption, assume 60 lb. of steam per kilowatt-hour.

(b) Assume 8 lb. of steam per pound of coal.

(c) and (d) The cost of coal and the proportion of the total steam generated which is used in the heating system, are both variable. In the figures given herewith, the cost of coal ranges from $1 to $5 per ton. The amount of steam used in the heating system is taken care of by considering it proportional to the number of months that the exhaust steam is used for heating. During those months it is assumed that all the exhaust steam is used by the heating system. Strictly speaking, at the beginning and end of the heating season, there are periods when only a moderate amount of heating is required and only a portion of the exhaust steam is utilized. This decrease in heating load may be taken care of by assuming a shorter heating season. For example, suppose that during the four winter months all the exhaust steam is used in heating and that for 1½ months before and after this season the amount of steam used in the heating system varied from zero to full capacity. It would then be quite accurate to assume that the heating season of seven months would be equivalent to a season of 5½ months in which the heating load was always equivalent to the full exhaust of the engine.

Water

An average price for water is 10c. per thousand gallons. During the heating season it is assumed that only 30 per cent. of the water is returned to the boiler; in other periods all the water is lost.

With the fixed costs and labor, as already given, and calculating the coal and water charges for given conditions, the charts shown were obtained. The following example will serve to explain in detail the method of obtaining these figures:

Example

Assume the heating season equivalent to six months of full-load steam heating, when all the exhaust is used. During this period the coal chargeable against power is the equivalent of the heat lost between the high-pressure boiler and the heating system. Assume that 20 per cent. of the heat of the steam is lost in this manner. The other factors entering into the coal cost have already been given, i.e., load 200 kw.; steam consumption 60 lb. per kilowatt-hour; evaporation 8 lb. of steam per pound of coal; hours per year, 3000. With coal at $4, the cost for coal chargeable to power during the six months' heating period would be:

$$200 \times \frac{3000}{2} \times \frac{60}{8} \times 0.20 \times \frac{\$4}{2000} = \$900$$

The part of the year when there is no exhaust-steam heating, and those times when only part of the exhaust steam is used for heating, are equivalent to six months of straight noncondensing operation. The cost of coal is therefore

$$200 \times \frac{3000}{2} \times \frac{60}{8} \times \frac{\$4}{2000} \qquad \$4500$$

To this coal cost must be added the cost for water, which may be set down at 10c. per thousand gallons. During the heating season, the heating system returns 80 per cent. of the boiler feed. The cost for water is then

$$200 \times \frac{3000}{2} \times \frac{60}{8.33} \times 0.20 \times \frac{10}{1000} = \$43.20$$

For the other six months the cost for water is as follows:

$$200 \times \frac{3000}{2} \times \frac{60}{8.33} \times \frac{10}{1000} = \$216$$

Therefore the total charges for generating power at the rate of 200 kw. for 3000 hr. a year are as follows:

Fixed charge	$1875
Labor, oil and miscellaneous	1050
Coal	4500
	900
Water	216
	43
Total	$8584

During the year there are developed 3000 × 200 = 600,000 kw.-hr., giving a cost per kw.-hr. of

$$\$8584 \div 500{,}000 = 1.431 \text{ cents}$$

In the same manner it is found that when the heating season is equivalent to only two months of full-load heating, the cost per kilowatt-hour is 1.85c. For the same conditions when the price of coal is $5 instead of $4, the cost per kilowatt-hour is 2.175c.

From these data the charts shown in Figs. 1 and 2 were prepared. In Fig. 2 the cost, exclusive of coal and water, is considered separately; being plotted against the load factor.

A load of 200 kw. for 3000 hr. per year is considered as a 100 per cent. load factor (although the plant capacity is 250 kw.). At this load the fixed charge, labor charge, etc., per kilowatt-hour is

$$\frac{\$1875 + \$1050}{600{,}000} = 0.488 \text{ cent}$$

Similarly, at 50 per cent. load factor the cost per kilowatt-hour, exclusive of coal and water, is

$$\frac{\$1875 + \$1050}{300{,}000} = 0.976 \text{ cent}$$

By similar calculations the curve is plotted, which may be used in connection with the curves at the right in order to study the cost of power under various conditions.

Suppose, for instance, that the load factor is 50 per cent., then the fixed charges, labor, etc., amount to $0.98. If the coal cost is $4 a ton and the number of months of exhaust-steam heating is 4; then the coal and water cost per kilowatt-hour is 1.17c. and the total cost of power per kilowatt-hour is 2.15c.

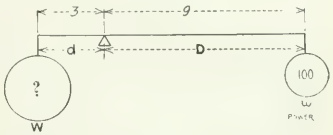
Study Questions

In accordance with the suggestion of a subscriber, who would like to work out some problems and be assured of the correctness of his results, but who finds the answers in the usual catechism too handy, we submit the following, the answers to which will be published next week:

1. A generator unit uses 16.5 lb. of steam per kilowatt-hour. What is the consumption per indicated horsepower-hour if the overall efficiency of the unit is 90 per cent.?

2. A boiler evaporates 8.5 lb. of water per pound of coal from feed having a temperature of 160 deg. into dry saturated steam of 135 lb. absolute pressure. What is the equivalent evaporation from and at 212 deg.?

3. What weight will be required at *W*



to balance a weight of 100 lb. at *w* when the distances are as given in the sketch?

4. How far would a body starting from rest drop in one second; in four seconds? Explain why, air resistance neglected.

5. If a boiler had its safety valve set to blow at 100 lb. gage at the sea level, what pressure would the gage show when the valve blew if the boiler were moved to an elevation where the pressure was one pound less per square inch?

Writing on electrical power in the Transvaal in *Cassier's Magazine* for February, Rowland Gascoyne gives the following schedule of prices as fixed by the Victoria Falls Power Co. for the supply of electrical energy.

Load factor, percentage	Price per unit (kw.-hr.) from Oct. 1, 1910, to Oct. 1, 1912, Pence	Price per unit after Sept. 30, 1912, Pence
10	2.512	2.475
15	1.754	1.717
20	1.375	1.338
30	0.995	0.958
40	0.807	0.770
50	0.692	0.655
60	0.617	0.580
70 and over	0.5617	0.525

The magnitude of this company's operations is understood when it is known that its capitalization is $30,000,000; its license allows an annual output up to 500 million kilowatt-hours, and its transmission lines extend over 50 miles.

Low Pressure Turbine Installation

By B. R. T. Collins

To meet the increased demand for power, a 1500-kw. low-pressure turbo-generator was installed in connection with one of the noncondensing Corliss engines.

According to the figures, the saving effected by this arrangement for the present year will amount to about twice the fixed charges on the additional investment.

A further demonstration of the economy to be obtained by the installation of a low-pressure turbine in connection with a Corliss engine has recently been made in the power plant of the Goodyear Tire & Rubber Co., of Akron, Ohio. A large proportion of the power developed by this plant is required to drive machinery in a department of the factory adjoining the engine room and is delivered to several lines of heavy shafting, with couplings direct to the machines, by a rope-drive system from a Corliss engine. The balance of the power required in the factory buildings, which cover an area of about 25 acres, is furnished by electric drive from a low-pressure turbo-generator using the exhaust steam from the engine together with that from various plant auxiliaries.

The Corliss engine is a 34 and 60 by 60-in. Hamilton horizontal cross-compound noncondensing machine rated at 2500 hp. and running at 80 r.p.m. It will be noted that a cylinder ratio of 1 to 3.1 is used in order to have an engine of low steam consumption when running noncondensing. The American system of rope drive is used to transmit the power from the engine to the line shafting.

There is also a 26 and 52 by 54-in. Fulton horizontal cross-compound condensing engine rated at 1200 hp. which is available for operation with the Hamilton engine and which also serves as a partial relay to it.

The low-pressure turbine is a 1500-kw. Allis-Chalmers machine direct connected to a three-phase, 60-cycle, 480-volt generator running at 1800 r.p.m.

The specified steam pressure at the low-pressure throttle is 15 lb. per square inch absolute or about 0.3 lb. gage at average atmospheric pressure. A back-pressure valve is placed in the exhaust line from the engine to the turbine and is adjusted to maintain a constant back pressure on the engine of about 1 lb. gage. This gives the engine a constant exhaust pressure to work against and at the same time prevents the vacuum from backing up through the turbine into the exhaust header which is 48 in. in diameter and 50 ft. in length and is more easily kept tight under pressure than under vacuum.

A high-pressure throttle is provided for supplying live steam to make up for any deficiency in the exhaust steam. The use of live steam is not likely to occur to any great extent, however, as the engine ordinarily operates 23 hr. per day and during the remaining two half-hour periods when it is shut down, the turbine load decreases also; moreover, all the auxiliaries which furnish a considerable percentage of the total exhaust steam to the turbine are in service 24 hr. per day.

The turbine condensing equipment consists of an Allis-Chalmers condenser, provided with two single-stage centrifugal pumps mounted on a common shaft coupled direct to a 175-hp. Terry steam turbine. One of these pumps, which has a double impeller, removes the condensed steam and water from the condenser body and the other delivers water from the cold well to the twin air ejectors. The water used by the latter pump is returned to the cold well and is used over again as its temperature is not increased materially by its passage through the ejector nozzles. A 28-in. vacuum is guaranteed with a full load of 1500 kw., 15 lb. absolute steam pressure at the throttle and injection water at not more than 70 deg. F.

As a partial relay for the low-pressure turbine, there is a 500-kw. Crocker-Wheeler motor-generator set, used ordinarily to convert alternating into direct current for the variable-speed motors. This can be operated inverted from a Cooper condensing engine direct-connected to a 300-kw. Westinghouse direct-current generator and thus provide relay capacity up to the overload limit of the engine-driven unit. This arrangement is also convenient for carrying the load on Sundays and at other times when the demand for power is light.

Later, it is proposed to provide more relay capacity by installing an auxiliary turbine which can be coupled to the motor-generator set in an emergency and which will provide sufficient power to generate 1000 kw. divided equally between alternating and direct current.

A test recently made on the low-pressure turbine showed a steam consumption of 32.8 lb. per kilowatt-hour output of the turbine alone at a steady load of 1292.7 kw. under the conditions specified which is 6.3 per cent. better than the maker's guarantee at this load.

Considering the engine and turbine as a unit, a water rate of 16.95 lb. per kilowatt-hour was obtained.

In order to make a comparison of this result with the steam consumption previous to the installation of the turbine, when the load was carried by two independent compound-condensing engines, it was necessary to add 10 to 15 per cent. to the foregoing figures to compensate for the variable load, as the comparative data were obtained from a 24-hr. test of the complete plant on Sept. 13 to 14, 1911. This test showed a steam consumption of 26.55 lb. per kilowatt-hour for both engines taken together carrying an average of 992.7 equivalent kilowatts for the 24-hour test period.

Adding 15 per cent. for the variable load on a 24-hour test, to 16.95 lb., the result obtained on the steady load combined engine and turbine test gives 19.49 lb. per kilowatt-hour for the comparative steam consumption as against 26.55 lb. for the two engines. This shows a gain of 7.06 lb. per kilowatt-hour, or 26.6 per cent. in favor of the turbine and engine.

The cost of the 1500-kw. low-pressure turbine installation was $38,300, including the condenser, piping, separators, expansion joints, special valves, foundations, etc., but not including the switchboard or the building. This is equivalent to about $25 per kilowatt. The cost of the 2500-hp. noncondensing engine installation was $32,000, including the piping, separator, valves, foundations, etc., but not including the building, making about $13 per horsepower.

This makes the installation cost of the combined engine and low-pressure turbine unit $70,300. The fixed charges on this amount, taking interest at 5 per cent., depreciation at 5 per cent., taxes at 1½ per cent. and insurance at 1 per cent., or a total of 12½ per cent., would be $8787 per year. The cost of operating the plant with two condensing engines during the year 1911 was $63,457. Assuming that there would have been an increase of one-third in this operating cost, during the present year, due to increased demand for power, under the old conditions, this would amount to $84,609 for the probable operating cost for 1912. Taking an average yearly saving of 20 per cent. due to the new installation of an engine and low-pressure turbine, based on the 26.6 per cent. saving as shown by the tests referred to, there would be $16,920 as the probable yearly saving due to the new machinery or nearly twice the fixed charges of $8787 on the entire installation cost.

Comparing the cost of the engine and low-pressure turbine unit as installed with the cost of a high-pressure tur-

bine installation of similar capacity shows the following: A high-pressure turbine rated at 2000 kw. with 25 per cent. continuous overload capacity and 50 per cent. overload for two hours, with 175 lb. steam pressure, no superheat, a 28-in. vacuum and running at 1800 r.p.m., would have very nearly the same equivalent capacity as the engine and low-pressure turbine unit under discussion; if anything, the capacity would be less than the combined unit. The installed cost of such a high-pressure unit would be about $45,500, including the condenser, piping, separator, expansion joints, foundations, etc., but not including the switchboard or building so as to correspond with the costs of the combined unit. This cost is based on actual proposals for turbine, condenser, etc., and should be very close to the actual cost under the conditions at this particular plant.

Comparing this figure with the actual cost of the engine and low-pressure turbine, $70,300, shows an increased cost of $24,800 for the combination, and taking 12½ per cent. of this gives $3100 per year for fixed charges on the additional investment required.

A comparison in steam consumption between the engine and low-pressure turbine combination and the high-pressure turbine alone as heretofore given, shows a lower consumption at full load for the combined unit by 8.4 per cent. If it is assumed that this difference would exist at the average load carried during the year, which would probably be somewhere between three-quarters and full load, and taking the yearly cost of operation at $84,609 as before, 8.4 per cent. of this cost, or $7107, would represent the yearly saving in favor of the engine and low-pressure turbine unit. This is more than twice the yearly fixed charges of $3100 on the additional investment required for the latter.

In conclusion, it may be said, that from the results of the tests and comparisons given above, the conclusion would be warranted that there is sufficient margin between the steam consumption of a unit composed of a noncondensing engine and low-pressure turbine as compared with a high-pressure turbine, under the conditions described, to unquestionably throw the decision in favor of the engine and low-pressure turbine and warrant the additional expenditure required for them.

Steam Leakage Past Piston Valves

The Feb. 9 issue of *The Engineer* contains a very interesting account of some investigations recently conducted by H. D. Lobley at the University of Birmingham to determine the loss of steam due to leakage past a piston valve.

A striking feature of these tests is that the results are quite contrary to those obtained by Callendar and Nicolson in a similar series of tests carried out in 1897. Mr. Lobley's results indicate that the loss due to leakage past a piston valve is comparatively small, whereas the conclusion from Callendar and Nicolson's experiments was that this loss formed a large part of the "missing quantity," a term used to designate the thermal losses within the steam-engine cylinder.

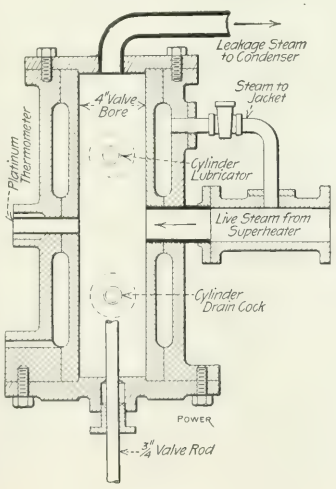
The experiments as conducted by Mr. Lobley were made with an ordinary 4-in. piston valve fitted with four ramsbottom spring rings and taken from stock. The valve was fitted into a jacketed cylinder and was driven at various speeds by a motor. Steam was supplied from the boiler or superheater to the center of the valve and the leakage was taken from the end. This steam was led to a condenser and after being condensed was carefully weighed. The illustration shows a section through the cylinder. A steady flow of steam was allowed to blow through the jacket so as to prevent stagnation and a corresponding reduction in temperature which probably would have occurred if the amount of steam used had been only that due to leakage.

During each of the tests, readings were taken every 15 min. The first run was made with superheated steam, a boiler pressure of 200 lb. per square inch and variable speeds; the second was at the same steam pressure with a constant speed and at different degrees of superheat; the third was with saturated steam at different pressures and a constant speed. The results are shown in the accompanying tables.

The loss due to leakage alone depends upon the pressure difference and the speed; also, it is much less where superheated steam is used.

The total leakage, however, was found to be comparatively small.

As a means of comparison with Callendar and Nicolson's results, Mr. Lobley applies his own figures to the formula deduced by them and then solves for the leakage coefficient. This expression is as follows:



SECTION THROUGH VALVE CHEST

$$K = \frac{CP}{L}$$

where,

K = Rate of leakage per hour per pound difference of pressure;
P = Perimeter of port;
L = Mean overlap of valve;
C = Leakage coefficient.

Although these terms were originally applied to a slide valve, in the case of a piston valve, P would represent the circumference of a ring and L would be the sum of the widths of the rings, representing the length of the contact surface. The assumption was made that the leakage past the two portions of the valve was equal.

TABLE 1. SUPERHEATED STEAM

Trial	Speed in R.p.m.	Temperature of Steam, Deg. F.	Boiler Gage Pressure, Lb. per Sq.In.	Leakage in Lb per Hour
A 1	200	407	200	4 825
B 2	150	396	200	4 82
B 3	100	392	200	4 9
B 4	50	397	200	4 8
B 5	(standing)	409	200	2 1

TABLE 2. SUPERHEATED STEAM

Trial	Speed in R.p.m.	Temperature of Steam, Deg. F.	Boiler Gage Pressure, Lb. per Sq.In.	Leakage in Lb. per Hour
A 1	200	407	200	4 825
A 2	200	452	200	3 66
A 3	200	498	200	2 70
A 4	200	557	200	3 075
A 5	200	588	200	3 275

TABLE 3. SATURATED STEAM

Trial	Pressure in Lb per Sq In	Speed in R.p.m.	Leakage in Lb. per Hour
C 1	156 1	200	7 8
C 2	128	200	7 5
C 3	80	200	6 6
C 4	37 1	200	4 9
C 5	152	(standing)	3 86

Table 4 shows the values of C calculated from the saturated-steam tests with variable pressure differences.

From this an average value of 0.0022 is obtained for C, or about one-tenth of that found by Callendar and Nicolson. The value of C, however, is not constant,

TABLE 4. LEAKAGE COEFFICIENT

Pressure Difference	Leakage in Lb. per Hour	K	C
141	7.8	0.0276	0.0013
113	7.3	0.05325	0.00132
65	6.6	0.05675	0.00202
22.4	4.9	0.1095	0.00435

although it does not vary directly with the pressure difference. The relative amount of this leakage, according to Mr. Lobley's results, may be arrived at closely by considering that a 4-in. piston valve would handle about 1500 lb. of steam per hour. The valve when running at a temperature of 557 deg. F leaks only 3.075 lb. of steam per hour. This represents only about 0.2 per cent. of the steam handled.

The effect of temperature upon the leakage is clearly shown by the tests. By slightly superheating the steam, the leakage was reduced from 7.8 to 4.8 lb. per hour.

An explanation of this is given, based upon the condensation and reëvaporation theory. This is to the effect that the space between the two portions of the valve is constantly in contact with steam at a high temperature while the exhaust side is exposed to the comparatively cold steam at atmospheric pressure. When the valve begins to move it exposes a cold portion of the liner and some hot steam is immediately condensed. The film of water thus formed allows the rings to pass over it, and upon emerging on the exhaust side of the valve it evaporates again. With superheated steam, the cold walls are heated to a large extent at the expense of the superheat and much less condensation results

Chimneys for Dissipating Smoke

By Dr. Alfred Gradenwitz

A new arrangement effecting a thorough dilution of smoke and air has been invented by Dr. H. Wislicenus and is being promoted by a German metallurgical firm (Metallbank und Metallurgische Geselleschaft, at Frankfort-on Main). This "dissipator," as it is called, is based on the following principle:

Instead of escaping from the top of the chimney in the usual manner, the exhaust gases are caused to leave through a number of approximately horizontal air channels, proportioned to their rise, and becoming more and more diluted before escaping through the slots. The air channels are widened out conically, which design is especially favorable for the formation of whirls and for insuring a thorough mixture. All heavy smoke, with a strong wind, is thus dissolved into a foggy mist, while with a light wind it is at least thoroughly distributed and diluted.

The shape and dimensions of the air channels can be varied in many ways so as to further assist the dissipator action; by a tangential arrangement (Fig. 3), by a double funnel-shaped air channel (Fig. 4) or by an extension of part of the channels into diverging passages (Fig. 5). All these modifications have been protected by letters patent.

Fig. 1. Dissipator Stack Compared with Ordinary Chimney When Handling Moderate Amount of Smoke

Fig. 2. Stack Handling Heavy Tar Smoke, Notice How Smoke Is Diluted

mass and the rate of flow. The gases are thus whirled through with the air current within the dissipator chimney and in its immediate neighborhood, without affecting the draft.

The upper part of the chimney, one-fourth to one-third of its height, is latticed (see Fig. 1). In this section the air currents are mixed on one side in the funnel-shaped or slot-like channels with the rising current of exhaust gases, the air currents deviating and changing their speed so as to produce a whirling action. The mixture thus formed escapes through the air channels on the opposite side. Only a small part of the gases escapes through each series of channels, the remainder continuing to

Whenever in the place of a draft chimney, a channel mouth terminating on the level or on some roof or hill has to be dealt with, the discharge shaft can be designed with multiple gratings, insuring a more thorough mixture (see Fig. 6). The first instance of such a "multi-dissipator" chimney is a stack erected in connection with a Winkler washing cham-

Fig. 3

Fig. 4

Fig. 5

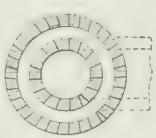


Fig. 6

Different Forms of Dissipator Chimneys

ber (for removing acids), while an improved plant consisting of radial bricks —with a moist ventilator and limestone plant for the removal of acids—was installed for a large German dyeing and bleaching works. These chimneys, on account of the convenient distribution of their slots, are of a pleasing appearance, and their stability has been found

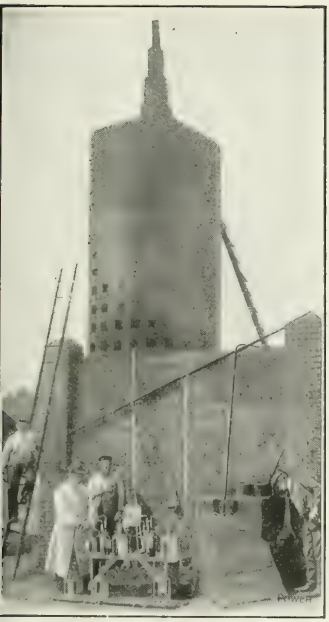


FIG. 7. FIRST EXPERIMENTAL MULTI-DISSIPATOR STACK, SHOWING SMOKE DILUTED INTO A HAZE

to be quite as satisfactory as that of ordinary stacks.

Fig. 7 shows the first multi-dissipator constructed by Dr. Wislicenus and illustrates how the smoke is dissolved into a foggy mist.

"Albany" Shaking Grate

George H. Thacher & Co., Albany, N. Y., manufacture the "Albany" shaking grate herewith illustrated. For the larger sizes of furnace the grate area is divided into four quarters, each of which shakes as a unit as indicated in Fig. 1. All parts are standardized and completely interchangeable, there being no right- or left-hand grates. The grate bars are triangular in shape which, it is claimed, gives the best distribution of metal and the greatest strength and durability.

The individual parts of the grate are shown in Fig. 3, while Fig. 2 shows them assembled. The bearing bar *A* is set in the brickwork and carries the side frame *B* as shown. The end pieces *C* fit into the wedge-shape slots in the side frames. The grate-bar frames *D* are carried in bearings in the side frames and are joined together underneath by the connecting bar *E*, to which the connecting-rod *K* is attached. The grate surface proper is composed of a number of grate sections *O* which fit into the grate-bar frame and are fastened in place by a split pin which passes through the lug on the section and the bottom member of the frame, as shown in the lower part of Fig. 1. The advantage of this construction is that the amount of air space of any installation may be changed simply by changing the grate sections *O* without making any change in the rest of the installation and when a section burns out only that section has to be replaced and not a whole bar. These grate sections are made in several sizes to give any percentage of air space from a ¼-in. opening for fine fuels up to a ¾-in. opening, for bituminous lump coal. In addition, sections with pinhole openings may be obtained for especially fine fuels.

The journals at the ends of the grate-bar frames are flattened on the top and a section somewhat smaller in width than the diameter of the journal is cut out of the top part of the bearings. Thus, any frame may be lifted out of its bearings and removed entirely by simply disconnecting it from the connecting bar and turning the frame at an angle of 90 deg.

During the shaking operation of the grate, when the sections are tilted, a wedge-shape pocket is formed by the top of one section and the side of the next into which the under stratum of ash is pushed by the first motion of the grate. When the sections are again brought back to the normal position, this ash is cut off from the live fuel and dropped into the ashpit. This pocket-forming arrangement tends to prevent the loss of unburnt fuel to the ashpit.

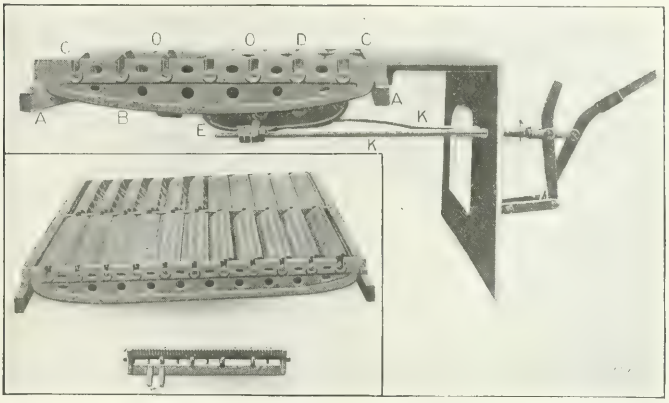


FIG. 1. THE "ALBANY" SHAKING GRATE FIG. 2. SHOWING ASSEMBLY OF PARTS

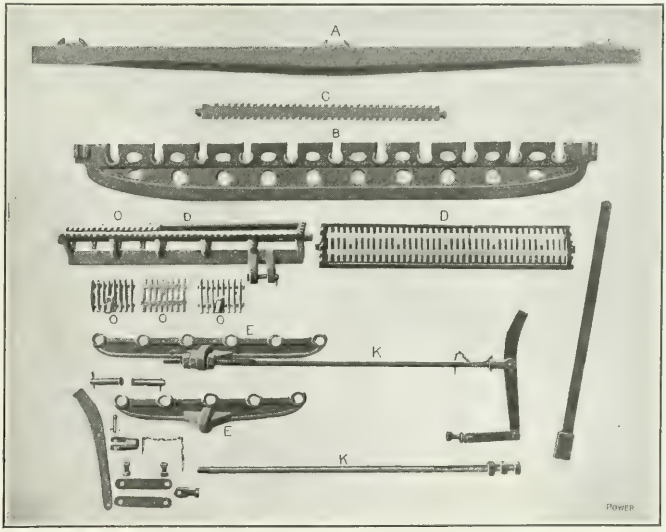


FIG. 3. SHOWING INDIVIDUAL PARTS OF THE "ALBANY" SHAKING GRATE

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Wires for Direct-current Circuits

By Cecil P. Poole

There are two ways of getting at the proper size of wire to use for electric circuits in order to keep the line loss within desired limits; one by considering the power transmitted and the other by considering the current strength, regardless of the power. The former method is more easily applied in alternating-current work, but the latter is simpler of application in direct-current work.

No matter which method may be used, however, the current per wire must be considered, either directly or indirectly, in the case of indoor wiring because the fire insurance authorities will not allow more than a certain current to be carried by each standard size of wire, in order to guard against overheating. Table 1 specifies the maximum allowable current for every standard size of copper wire in regular use for power and lighting circuits in the United States. It also shows what the drop in voltage is per foot of each size of wire, for each ampere of current carried; the drop per foot of distance (for a two-wire circuit) per ampere of current; the drop in volts and the loss in watts per foot of distance when carrying the greatest allowable current, and the drop and lost watts per foot of distance when carrying four-fifths of the greatest allowable current. This last group of figures applies essentially to motor circuits and shows the greatest drop and the greatest loss per foot of distance that are allowable under the insurance rules. The rules require that wires used for connecting motors to supply circuits shall be large enough to carry 25 per cent. more than the full-load current of the motors.

For example, No. 4 wire with rubber insulation is allowed to carry only 65 amperes, maximum. Therefore, a motor connected up with this size of wire must not take more than 80 per cent. of 65 amperes ($0.8 \times 65 = 52$ amperes) at full load, because the 25 per cent. margin required will make the maximum current $52 \times 1.25 = 65$ amperes. Neither the drop nor the loss at 65 amperes, in such a case, is important, because that current would exist only for a few moments while starting the motor and perhaps occasionally when momentary overloads occur. It is the full-load drop and loss that are of importance; that is why columns 10, 11, 14 and 15 were put in Table 1.

The usefulness of these columns lies in showing by a single simple multiplication whether a given size of wire can be used for a given drop. For example, suppose a 220-volt motor is to be put in at a distance from the mains of 75 ft., and a drop of 1 per cent. is desired at full load. Also suppose that you have on hand a lot of No. 4 and No. 6 rubber-covered wire but no other near sizes. At 1 per cent. drop over a distance of 75 ft. the drop per foot would be

$$\frac{0.01 \times 220}{75} = 0.0293$$

of a volt. Reference to the tenth column of the table shows that the greatest allowable drop for No. 4 is 0.0263 of a volt and that for No. 6 is 0.0296; therefore, the No. 6 wire can be used.

The drop columns are useful also in determining the limits of drop in another way. For example, suppose a 250-volt motor requiring 60 amperes at full load is to be installed at a distance of 150 ft. from the mains and the drop must not exceed 2 per cent., which would be 5 volts. What size of rubber-insulated wire should be used? According to the fourth column of the table, No. 3 wire could be used without exceeding the insurance limits, because 60 amperes plus 25 per cent. would make the maximum current 75 amperes and the insurance rules allow 76. But would the drop come within the limit of 2 per cent.? According to column 10, the allowable full-load drop per foot of distance is 0.0244 of a volt, so that for 150 ft. the full-load drop would be $150 \times 0.0244 = 3.66$ volts which comes well within the specified limit of 5 volts.

Columns 12 to 15 correspond to columns 8 to 11; they give the loss in watts under the same conditions for which columns 8 to 11 give the drop in volts. This is useful in cases where the current is not stated but the power is. For example, if it were known that 39 kw. had to be transmitted 260 ft. from a 220-volt line with a loss of not more than 2 per cent. it would not be necessary to divide 39,000 by 220 to find the line current; then see how small a size of wire would satisfy the fire-insurance rules, and finally figure the drop to see if it came within the 2 per cent. limit. All that is required is to divide 2 per cent. of 39,000 by 260 to get the loss in watts per foot of distance and find the nearest larger number in column 12; this number is 3.22 and the size of wire at the left-hand end of the same line of type is No. 0. Therefore, No. 0 can be used to satisfy both the insurance and the loss requirements.

Column 8 would not apply to this case without checking up the insurance requirements separately. Thus, the loss being 2 per cent. or less, the drop will be 2 per cent. or less. Now 2 per cent. of 220 volts is 4.4 volts, and this would be a drop of $4.4 \div 260 = 0.0169$ volt per foot. Column 8 gives no intimation as to whether one should use wire of 400,000 circ.mils cross-section, with a maximum drop of 0.0174 volt per foot of distance, or some of the smaller sizes, which are all capable of a higher drop per foot of distance. The *current* must be known in order to use columns 7 to 11. These columns are very useful, however, when the current is known, and it usually is.

Columns 8 to 15, although highly convenient in cases where the current is near the maximum allowed by the insurance rules for one of the standard sizes of wire, are not of much service in dealing with currents which fall between the insurance limits for neighboring wire sizes. For example, with a current of 64 or 65 amperes, this table shows at once whether No. 4 rubber-insulated (or No. 6 weatherproof) wire will give the desired drop or loss. But if the full-load current of a motor happened to be, say, 48 amperes, Table 1 would not show what the drop would be with any size of wire allowed by the insurance rules, except by the use of the figures in column 7, which involves at least two probably tedious calculations. Adding the 25 per cent. margin required would carry the current up to 60 amperes maximum allowance. With rubber-covered wire, any size larger than No. 5 could be used, and the drop would be less than 0.0263 volt per foot of distance; with No. 4 it would be $\frac{60}{65}$ of 0.0263, with No. 3 it would be $\frac{60}{76}$ of 0.0263, with No. 2 $\frac{60}{87}$ or $\frac{3}{4}$ of 0.0263, and so on. The determination of the drop, however, requires a good deal of tiresome arithmetic, applied on the cut-and-try plan.

In order to avoid this, with the attendant possibilities of arithmetical error due to haste or the misplacement of a decimal point, Table 2 is provided. This shows for each size of wire the product of amperes $\times$ feet corresponding to different drops in voltage from $\frac{1}{4}$ to 60 volts. For example, if the cur-

rent multiplied by the distance were equal to 50,000, the drop with No. 0000 wire would be 5 volts; with No. 0 wire 10 volts; with No. 2 wire about 16 volts; with No. 5 wire 32 volts, etc. The table was computed on a calculating machine and the number of figures in each of the large numbers is therefore greater than is really necessary.

Finding the Size of Wire

For finding the proper size of wire to use for a given load, distance and drop, multiply the current by the distance and in the line with the desired drop, find the nearest number to the product of current × feet; at the head of the column in which that number is located will be found the size of wire.

Example I. A pair of wires 180 ft. long must carry 100 amperes with a drop of about 3 volts; what size of wire should be used?

The distance being 180 ft. and the current 100 amperes, the product (amperes × feet) is 18,000. The drop is to be 3 volts; starting at 3 in the drop column and following along that line, the nearest number to 18,000 ampere-feet is 18,915, which is located in the fourth column of the table, and the size of wire at the top of that column is No. 00. Now, this size must be checked for insurance limitation. Table 1 shows that No. 00 is allowed to carry 150 amperes with rubber insulation or 220 with other kinds, so that it is within the limit, even for motor service.

Example II. A 250-volt motor requiring 75 amperes at full load must be connected to a supply circuit 700 ft. away, and as the connecting wires are out of doors, weatherproof wire can be used. It is desired that the drop shall not be more than 4 per cent., which, of course, is 10 volts. What size of wire should be used?

The current × distance will be 52,500 and starting at 10 volts in the drop column it will be found that 50,000 is the nearest number to 52,500; it is located in the No. 0 column and immediately below it is the number 55,000, which is in the line with 11 volts drop. Therefore, if No. 0 wire be used, the drop will be half-way between 11 volts and 10 volts, or 10½. If it is important to keep the drop within 10 volts, No. 00 wire must be used. The nearest number to 52,500 in this column is 50,440, in the line with 8 volts drop; the actual drop with this size of wire, therefore, would be between 8 and 9 volts, because the amperes × feet are 52,500, whereas with No. 00 wire they would have to be 50,440 to give 8 volts drop or 56,745 to give 9 volts drop.

Finding the Drop

From the last example it should be clear that when the current, distance and wire size are known the drop can be found, at least approximately, from Table 2 by multiplying the current and distance together, finding the nearest number to the product in the column under the wire size and following along that line to the drop column.

Example III. A pair of No. 8 wires 25 ft. long carry 28 amperes; what is the drop?

The current × distance = 700; the nearest number to this in the No. 8 column of Table 2 is 782 and this is in

TABLE 1 PROPERTIES OF COPPER WIRES
Brown & Sharpe Gage

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
			Greatest Allowable Current*				Volts drop per foot of distance,† carrying maximum current.		Volts drop per foot of distance† with 80° of maximum current.		Watts lost per foot of distance,† with maximum current.		Watts lost per foot of distance;† 80° of max. current.	
Wire Size; No.	Diameter in Mils	Area in Circular Mils	Rubber Insul.	Other Insul.	Volts Drop per Ampere per Foot of Wire	Volts Drop per Ampere per Foot of Distance†	Rubber Insulation	Other Insulation	Rubber Insulation	Other Insulation	Rubber Insulation	Other Insulation	Rubber Insulation	Other Insulation
		2,000,000	1050	1670	0 00000528	0 00001056	0 01109	0 01763	0 00887	0 01411	11 64	29 44	7 45	18 84
		1,900,000	1010	1610	0 00000556	0 00001112	0 01123	0 01790	0 00900	0 01432	11 34	28 81	7 26	18 44
		1,800,000	970	1550	0 00000586	0 00001173	0 01138	0 01818	0 00910	0 01455	11 04	28 17	7 06	18 03
		1,700,000	930	1490	0 00000621	0 00001242	0 01155	0 01851	0 00924	0 01480	10 74	27 58	6 87	17 65
		1,600,000	890	1430	0 00000660	0 00001320	0 01175	0 01888	0 00940	0 01510	10 45	27 00	6 69	17 27
		1,500,000	850	1360	0 00000704	0 00001408	0 01197	0 01915	0 00957	0 01532	10 17	26 04	6 51	16 67
		1,400,000	810	1290	0 00000754	0 00001508	0 01221	0 01945	0 00977	0 01556	9 89	25 09	6 33	16 05
		1,300,000	770	1220	0 00000812	0 00001624	0 01250	0 01981	0 01000	0 01585	9 62	24 16	6 15	15 46
		1,200,000	730	1150	0 00000880	0 00001760	0 01285	0 02024	0 01028	0 01619	9 38	23 27	6 00	14 89
		1,100,000	690	1080	0 00000960	0 00001920	0 01325	0 02074	0 01060	0 01659	9 14	22 40	5 85	14 33
		1,000,000	650	1000	0 00001056	0 00002112	0 01378	0 02112	0 01098	0 01689	8 92	21 12	5 71	13 51
		900,000	600	920	0 00001173	0 00002346	0 01408	0 02158	0 01126	0 01726	8 44	19 85	5 40	12 70
		800,000	550	840	0 00001320	0 00002640	0 01452	0 02218	0 01162	0 01774	7 97	18 63	5 10	11 92
		700,000	500	760	0 00001510	0 00003020	0 01510	0 02295	0 01208	0 01836	7 55	17 44	4 83	11 16
		600,000	450	680	0 00001760	0 00003520	0 01584	0 02394	0 01267	0 01915	7 12	16 28	4 55	10 42
		500,000	390	590	0 00002112	0 00004225	0 01648	0 02493	0 01316	0 01994	6 42	14 70	4 11	9 41
		400,000	330	500	0 00002640	0 00005280	0 01742	0 02640	0 01394	0 02112	5 74	13 20	3 67	8 44
		300,000	270	400	0 00003520	0 0000704	0 01900	0 02816	0 01521	0 02253	5 13	11 26	3 28	7 21
		200,000	200	300	0 00005278	0 0001056	0 02112	0 0317	0 01690	0 02534	4 22	9 51	2 70	6 08
0000	460 0	211,600	210	312	0 0000499	0 000100	0 02100	0 0312	0 01680	0 02496	4 41	9 73	2 82	6 23
000	409 6	167,770	177	262	0 0000630	0 000126	0 02230	0 0330	0 01784	0 02641	3 94	8 64	2 52	5 53
00	364 8	133,000	150	220	0 0000793	0 000159	0 02385	0 0350	0 01908	0 02798	3 57	7 70	2 29	4 92
0	324 9	105,560	127	185	0 000100	0 000200	0 02540	0 0390	0 02032	0 03120	3 22	7 21	2 06	4 61
1	289.3	83,690	107	156	0 000126	0 000252	0 0270	0 0393	0 02157	0 03145	2 88	6.13	1 84	3 92
2	257.6	66,360	90	131	0 000159	0 000318	0 0286	0 0417	0 0229	0 03332	2 57	5 46	1 64	3 49
3	229.4	52,625	76	110	0 000201	0 000402	0 0306	0 0442	0 0244	0 03537	2 32	4 86	1 48	3 11
4	204 3	41,740	65	92	0 000253	0 000506	0 0329	0 0465	0 0263	0 0372	2 13	4 27	1 36	2 73
5	181.9	33,090	54	77	0 000319	0 000638	0 0345	0 0491	0 0276	0 0393	1 86	3 78	1 19	2 42
6	162.0	26,245	46	65	0 000402	0 000804	0 0370	0 0523	0 0296	0 0418	1 70	3 40	1 09	2 17
8	128 5	16,512	33	46	0 000639	0 001278	0 0422	0 0588	0 0337	0 0470	1 39	2 70	0 889	1 73
10	101.9	10,384	24	32	0 001017	0 002034	0 0488	0 0651	0 0390	0 0521	1 17	2 08	0 749	1 33
12	80.8	6,530	17	23	0 001617	0 003234	0 0550	0 0744	0 0440	0 0595	0 935	1 71	0 598	1 09
14	64.1	4,107	12	16	0 00257	0 00514	0 0617	0 0822	0 0493	0 0658	0 740	1 31	0 473	0 842
16	50 8	2,583	6	8	0 00409	0 00818	0 049	0 0654	0 0393	0 0523	0 294	0.523	0.188	0 334
18**	40.3	1,624	3	5	0 0065	0 013	0 039							

*The limit (in amperes) allowed by the fire insurance rules for indoor wiring. For outdoor overhead wires, twice these figures may be allowed without danger of overheating.
†For a two-wire circuit.
**This size is allowed indoors only in flexible lamp cords.

he same line with 1 volt; the drop, therefore, will be between 1 volt and ¾ volt —nearer 1 volt.

Example IV. An outdoor line of No. 2 weatherproof wire carries 200 amperes 40 ft. from a 230-volt circuit to a factory building containing lamps and notors; what is the voltage at the entrance to the building?

The current × distance = 28,000. The nearest number to this in the No. 2 wire column of Table 2 is 28,300, which is n the line with 9 volts. Therefore, 28,-300 amperes × feet would give 9 volts drop and 28,000 will give $\frac{28{,}000}{28{,}300}$ of 9 volts, or 8.9 volts drop. The voltage at he factory building, therefore, will be 230 — 8.9 = 221.1 volts.

Finding the Practical Current

It sometimes happens that an old existing feeder or distribution main can be put into use to carry part of an extension load or for some other purpose, and it is desired to know about how much load it will be practical to put on it. The first step in such a case would be to find out whether the line will carry the full insurance allowance without too much drop. This is more quickly done with Table 1, using the drop columns at the right. If the drop is too great with the current allowed, then Table 2 will be more convenient for finding how much current can be carried without too great a drop.

Example V. It is desired to load a pair of No. 4 rubber-covered wires 100 ft. long as heavily as possible without making the drop exceed 2½ volts; how much current will the line carry?

The allowable drop is 2½ volts and the distance 100 ft.; the drop per foot, therefore, must not exceed

$$\frac{2\frac{1}{2}}{100} = 0.025$$

of a volt. The eighth column of Table 1 shows that the drop per foot of distance in a pair of No. 4 rubber-insulated wires carrying maximum current is 0.0329 of a volt, which is much beyond the desired limit of 0.025 of a volt per foot.

The required current can be found quickly from Table 2. In the line with 2½ volts drop and the column under No. 4 wire is the number 4940. This is amperes × feet, so that dividing it by the

TABLE 2. RELATION BETWEEN DROP AND CURRENT × DISTANCE

The numbers in the body of the table are amperes × feet for a two-wire circuit

Volts Drop	Size of Wire, B & S Gage														
	0000	000	00	0	1	2	3	4	5	6	8	10	12	14	16
¼	2,505	1,984	1,576	1,250	990	786	622	494	392	311	195	123	77	48	30
½	5,010	3,968	3,152	2,500	1,980	1,572	1,243	988	783	622	390	246	154	97	61
¾	7,515	5,952	4,728	3,750	2,975	2,358	1,865	1,482	1,175	933	586	369	231	145	91
1	10,020	7,936	6,305	5,000	3,968	3,145	2,487	1,976	1,567	1,244	782	492	309	194	122
1¼	12,525	9,920	7,880	6,250	4,960	3,930	3,109	2,470	1,959	1,555	978	615	386	243	152
1½	15,030	11,900	9,457	7,500	5,950	4,717	3,731	2,964	2,351	1,866	1,174	737	463	292	183
1¾	17,535	13,890	11,034	8,750	6,945	5,503	4,353	3,458	2,742	2,177	1,369	860	541	340	213
2	20,040	15,870	12,610	10,000	7,936	6,289	4,975	3,952	3,134	2,487	1,565	983	618	389	244
2¼	22,545	17,855	14,185	11,250	8,927	7,075	5,595	4,445	3,525	2,799	1,761	1,106	695	437	274
2½	25,050	19,840	15,760	12,500	9,920	7,861	6,219	4,940	3,918	3,109	1,956	1,229	773	486	305
2¾	27,555	21,825	17,340	13,750	10,910	8,647	6,840	5,430	4,310	3,420	2,152	1,352	850	535	335
3	30,060	23,810	18,915	15,000	11,904	9,434	7,462	5,928	4,700	3,731	2,347	1,475	927	583	366
3½	35,070	27,775	22,065	17,500	13,885	11,005	8,706	6,915	5,485	4,353	2,739	1,721	1,082	680	427
4	40,080	31,745	25,220	20,000	15,870	12,575	9,950	7,905	6,269	4,975	3,130	1,967	1,236	778	488
4½	45,090	35,710	28,370	22,250	17,855	14,150	11,190	8,890	7,050	5,597	3,521	2,212	1,391	875	549
5	50,100	39,680	31,525	25,000	19,840	15,720	12,437	9,880	7,837	6,219	3,912	2,458	1,546	972	610
5½	55,110	43,650	34,675	27,500	21,825	17,295	13,680	10,870	8,620	6,841	4,304	2,704	1,700	1070	671
6	60,120	47,620	37,830	30,000	23,810	18,868	14,925	11,855	9,400	7,463	4,695	2,950	1,855	1167	732
6½	65,130	51,585	40,980	32,500	25,790	20,440	16,170	12,845	10,185	8,085	5,086	3,196	2,009	1264	793
7	70,140	55,555	44,135	35,000	27,775	22,010	17,410	13,830	10,970	8,706	5,477	3,441	2,164	1361	854
7½	75,150	59,520	47,285	37,500	29,760	23,585	18,655	14,820	11,755	9,328	5,868	3,687	2,319	1459	915
8	80,160	63,490	50,440	40,000	31,745	25,155	19,900	15,810	12,540	9,950	6,260	3,933	2,473	1556	976
9	90,180	71,425	56,745	45,000	35,710	28,300	22,385	17,785	14,100	11,194	7,042	4,425	2,782	1750	1098
10	100,200	79,365	63,050	50,000	39,680	31,445	24,875	19,760	15,670	12,438	7,825	4,916	3,092	1945	1221
11	110,220	87,300	69,355	55,000	43,650	34,590	27,360	21,740	17,240	13,682	8,607	5,408	3,401	2140	1343
12	120,240	95,235	75,660	60,000	47,620	37,735	29,850	23,715	18,800	14,925	9,390	5,900	3,710	2334	1465
13	130,260	103,170	81,965	65,000	51,585	40,880	32,335	25,690	20,375	16,169	10,172	6,391	4,019	2529	1587
14	140,280	111,110	88,270	70,000	55,555	44,025	34,025	27,665	21,940	17,413	10,955	6,883	4,329	2723	1709
15	150,300	119,045	94,575	75,000	59,520	47,170	37,310	29,640	23,510	18,657	11,737	7,375	4,638	2918	1831
16	160,320	126,980	100,880	80,000	63,490	50,310	39,800	31,620	25,075	19,900	12,520	7,866	4,947	3112	1953
17	170,340	134,920	107,185	85,000	67,460	53,460	42,285	33,595	26,645	21,144	13,302	8,358	5,256	3307	2075
18	180,360	142,855	113,490	90,000	71,425	56,600	44,775	35,570	28,210	22,388	14,085	8,850	5,565	3501	2197
19	190,380	150,790	119,800	95,000	75,395	59,745	47,260	37,550	29,780	23,632	14,867	9,341	5,875	3696	2319
20	200,400	158,730	126,100	100,000	79,365	62,890	49,750	39,525	31,345	24,876	15,649	9,833	6,184	3891	2442
21	210,420	166,665	132,405	105,000	83,330	66,035	52,235	41,500	32,915	26,119	16,432	10,324	6,493	4085	2564
22	220,440	174,600	138,710	110,000	87,300	69,180	54,725	43,475	34,480	27,363	17,214	10,816	6,802	4280	2686
23	230,460	182,540	145,015	115,000	91,270	72,325	57,210	45,450	36,050	28,607	17,997	11,308	7,111	4474	2808
24	240,480	190,475	151,320	120,000	95,235	75,470	59,700	47,430	37,615	29,851	18,779	11,799	7,421	4669	2930
25	250,500	198,410	157,630	125,000	99,205	78,615	62,190	49,400	39,180	31,095	19,562	12,291	7,730	4863	3052
26	260,520	206,350	163,930	130,000	103,175	81,760	64,675	51,380	40,750	32,338	20,344	12,783	8,039	5058	3174
27	270,540	214,285	170,240	135,000	107,140	84,905	67,160	53,360	42,320	33,582	21,127	13,274	8,348	5252	3296
28	280,560	222,220	176,540	140,000	111,110	88,050	69,650	55,335	43,885	34,826	21,909	13,766	8,658	5447	3418
29	290,580	230,155	182,850	145,000	115,075	91,195	72,135	57,310	45,450	36,070	22,692	14,258	8,967	5642	3540
30	300,600	238,095	189,155	150,000	119,045	94,340	74,625	59,285	47,020	37,313	23,474	14,749	9,276	5836	3663
32	320,640	253,965	201,765	160,000	126,980	100,625	79,600	63,240	50,155	39,800	25,039	15,733	9,894	6225	3907
34	340,680	269,840	214,375	170,000	134,920	106,915	84,575	67,190	53,290	42,289	26,604	16,716	10,513	6614	4151
36	360,720	285,710	226,985	180,000	142,855	113,205	89,550	71,145	56,425	44,776	28,169	17,699	11,131	7003	4395
38	380,760	301,585	239,595	190,000	150,790	119,495	94,525	75,100	59,560	47,264	29,734	18,682	11,750	7392	4639
40	400,800	317,460	252,205	200,000	158,730	125,785	99,500	79,050	62 695	49,751	31,299	19,666	12,368	7782	4884
42	420,840	333,330	264,815	210,000	166,665	132,075	104,475	83,000	65,830	52,239	32,864	20,649	12,987	8171	5128
44	440,880	349,205	277,425	220,000	174,600	138,360	109,450	86,950	68,965	54,726	34,429	21,632	13,605	8560	5372
46	460,920	365,080	290,035	230,000	182,540	144,650	114,425	90,900	72,100	57,214	35,994	22,616	14,223	8949	5616
48	480,960	380,950	302,645	240,000	190,475	150,940	119,400	94,860	75,235	59,700	37,559	23,599	14,842	9338	5860
50	501,000	396,825	315,255	250,000	198,410	157,230	124,375	98,810	78,370	62,189	39,124	24,582	15,460	9727	6105
52	521,040	412,700	327,865	260,000	206,350	163,520	129,350								
54	541,080	428,570	340,480	270,000	214,285	169,800	134,325								
56	561,120	444,440	353,090	280,000	222,220	176,100	139,300								
58	581,160	460,315	365,700	290,000	230,155	182,390	144,275								
60	601,200	476,190	378,310	300,000	238,095	188,680	149,250								

distance will give the corresponding current:

$$\frac{4940}{100} = 49.4 \text{ amperes}$$

which is the current required to give 2½ volts drop.

SUMMARY, IN RULES

The methods of using the tables explained in the foregoing may be condensed into rules, as follows:

TABLE 1

TO FIND DROP: *Find in column 7 the number in the line with the size of wire; multiply it by the current and multiply the result by the distance. The final result will be the drop in volts.*

DROP, WITH GREATEST ALLOWABLE LAMP CURRENT: *In column 8 or 9 find the number in the line with the size of wire and multiply it by the distance. The result will be the drop in volts when the wire is carrying the greatest allowable current.*

DROP, WITH GREATEST ALLOWABLE MOTOR CURRENT: *In column 10 or 11 find the number in the line with the size of wire and multiply it by the distance. The result will be the drop when the largest allowable motor is taking full-load current.*

WATTS LOST WITH GREATEST LAMP CURRENT: *In column 12 or 13 find the number in the line with the size of wire and multiply it by the distance. The result will be the loss in watts when the wire carries the greatest allowable current.*

WATTS LOST WITH GREATEST MOTOR CURRENT: *In column 14 or 15 find the number in the line with the size of wire and multiply it by the distance. The result will be the loss in watts when the largest allowable motor is taking full load current.*

TO FIND WIRE SIZE: *Multiply the current by the distance and divide the desired drop by the product; find the nearest number to the result in column 7; this number will be in the line with the required wire size. Compare this with the insurance requirement.*

WIRE SIZE FOR GREATEST ALLOWABLE LOSS: *Divide the desired loss by the distance and find the nearest larger number to the result in column 12 or 13 for lamps or column 14 or 15 for a motor; this number will be in the line with the required wire size.*

TABLE 2

TO FIND DROP: *Multiply current by distance and find the nearest number to the product in the column under the size of wire. In line with this number will be the drop in volts. If the amperes × feet are greater than the nearest number in the table, the actual drop will be greater than the drop stated in column 1.*

TO FIND WIRE SIZE: *Multiply current by distance and find, in the line with the desired drop, the number nearest to the product. At the head of the column will be the size of wire to use. If the actual amperes × feet are greater than the number in the table, the actual drop will be greater than the drop in column 1.*

If any reader should find difficulty in applying these tables to his own work, a letter to the author describing the conditions and the difficulty will receive prompt attention.

Some Data on Central and Private Power Plant Operation

In a paper recently read before the National Gas Engine Association at Cleveland Rossiter Holbrook presented some statistics which are of much pertinence to the question of central-station service vs. isolated-plant operation.

The first group of figures was taken from the New York Edison Co.'s semi-annual report to the Public Service Commission for the second half of 1909. According to Mr. Holbrook, this report shows the following significant data:

Total output	120,000,000 kw.-hrs.
Total income	$7,231,602.62
Total station expenses	$1,318,570.21
Distribution expenses	1,210,108.84
General expenses	704,400.71
Taxes	402,943.21
Amortization	916,024.11
Uncollectible bills	92,860.08
Total expenses	$4,644,907.16
Total expense per kw.-hr.	3.87c.
Station expense per kw.-hr.	1.1 c.
Average income per kw.-hr.	6.02c.

From these figures it appears that all consumers paying less than 3⅞c. per kilowatt-hour are supplied at a loss which must be made up by charging small consumers extra-high rates. Mr. Holbrook also pointed out that the rate of amortization charged against the company's equipment is about 2 per cent., whereas in discussing isolated-plant operation, central-station representatives commonly figure 10 to 15 per cent.

Referring to the question of whether operating an isolated plant is profitable or not, Mr. Holbrook said:

> I should very much like to know why the Commonwealth Edison Co. is operating the plant in the Majestic Theater Building, on Monroe St., Chicago. The company bought this plant at a rather fancy figure, and if the managers had believed in their own talk, it would have been "junked"; but the company is operating it. The same condition exists at Gunther's, the Fisher Building, and the Chicago Title & Trust Building. In all these cases the landlord and tenants are getting bills from the Edison Co., which in turn is operating the landlords' own plant and making money on it.
>
> The New York Edison has installed a little isolated plant at its own coal yards instead of using current from its mains. If the central station will do these things—well, I will leave the rest to your good sense.
>
> I have reports from all over the country, such as the Great Northern, of Chicago, where the total operating expense for 1907 was less than $34,000, as against more than $64,000 for 1905, when central-station service was used; the Missouri Baptist Sanitarium, of St. Louis, that saves $1000 a year out of a total operating expense of less than $5000; the Sohmer Building (an office building), of New York, 29x100, 12 stories, with a yearly cost of $2761.25 for heat, light and power, including 120,000 kw.-hr. of electricity delivered from the plant. The Langsdorf Building, a loft building where the total operating cost for 1910, for light, heat and power amounted to $7757.39, and electricity alone from the Edison company would cost $8198.85. And I have here a report made by Mailloux & Knox on the plant in R. H. Macy & Co.'s store, installed in 1902. They have covered seven years—1903 to 1910—and the cost of electricity is 1.52c. per kilowatt-hour.

LETTERS

Demagnetizing a Watch

In the issue for Feb. 27, S. G. Rose asks for a method of demagnetizing watches. The alternating-current solenoid he describes is a very good method provided one has the current at hand.

A much simpler way of doing the job, however, is to suspend the watch by a strong cord; twist the cord so that when released the watch will spin for several seconds, release it, and while the watch is spinning slowly approach it with the positive pole of any strong magnet and then slowly withdraw the magnet. Do this a number of times and be sure that the magnet is not near the watch when it ceases to rotate or afterward. This method never fails.

C. C. HEYDER.

Hansford, W. Va.

An easy method of demagnetizing a watch is as follows:

Suspend the watch on a string about 2 ft. long and twist the string very tight so the watch will spin for some time when released. Then, holding the upper end of the string high enough to let the watch hang free, release the watch and allow the string to untwist and set the watch to whirling. As the watch whirls, walk toward the polepiece of a dynamo field magnet, and back away again. Doing this two or three times while the watch spins around usually cures the trouble.

THOMAS WILLIAMS.

Gypsy, W. Va.

[Exactly the same suggestion has been received also from W. T. Reeves, Adamston, W. Va.—EDITOR.]

A 1000-ft. ship will be built by Harland & Wolff, Belfast, for the White Star Co. The vessel will be driven at 18 knots by a combination of reciprocating engines and turbines, and her breadth will be 100 ft.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Reversing Gas and Oil Engines

By A. M. Levin

Although Americans hear only occasionally about reversing gas engines, Europeans show a decided partiality to them. The reversible marine gas motor, they say, eliminates the expense of a costly reversing gear, and by its adoption an outfit as light as possible will be obtained. The manipulation in reversing the engine consists simply in the throwing over of one or more reversing levers; excepting that the two-stroke-cycle engine requires generally, as a preliminary operation, to be unclutched from the propeller shaft.

A feature of the two-ported two-stroke-cycle engine in which the scavenging air is compressed in the crank case is that the direction of its motion is optional. The engine will, as is well known, run in whichever direction it is started. To reverse it when in operation, therefore, would seem a very simple matter, as a heavy charge preignited during the compression stroke will tend to do so. A number of patents relating to reversing devices based on this circumstance are on record; many, however, are of rather questionable worth.

Reversing by Preignition

In order that the desired result shall be obtained, it is necessary that the preignition pressure shall become high enough to overcome the inertia of the moving parts during the compression stroke, and, in addition, provide sufficient force to rotate the parts in the opposite direction until a new impulse can be obtained. These two requirements involve a series of others that, primarily, determine the conditions under which the reversal of the engine may actually be accomplished.

For instance, the energy stored in the flywheel, when revolving at full speed, is often several times that generated by a single explosion and, consequently, a first requisite will be to reduce the speed of the engine to a proper limit preliminary to reversal. What that limit should be, as well as what other requirements there are to be considered, will best be revealed by examining the reversing diagram.

In Fig. 1 is shown, in heavy lines, a regular full-load diagram of a two-stroke engine. Assume that, for the purpose of reversing the engine, the ignition be advanced so that preignition of the charge occurs during the compression stroke at the point *E*. The resulting explosion will carry the pressure along line *EF* to a point somewhat higher than the regular expansion line; due, essentially, to the scavenging effect created by some previous strokes during which the explosions have been cut out for the purpose of reducing the speed. From *F*, the charge becomes compressed along the line *FL* to a point *G*. The extent of this compression must evidently be such that the area *EFGHIE* shall represent the energy which the moving parts have transmitted to the charge in compressing it, counted from the time the explosion occurred. The available energy for compression of the gases being spent at the point *G*, the gases will from there

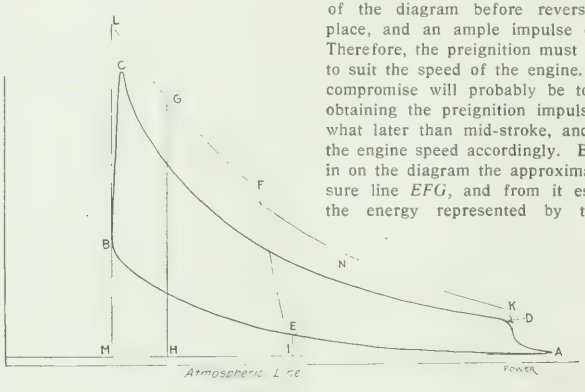


Fig. 1. Diagram of Reversal by Preignition

reëxpand; and in driving the piston backward, reverse the motion of the engine. The new expansion line, which will drop somewhat below the compression line *FG* due to the cooling of the charge, is represented by the line *GK*.

If the energy stored in the moving parts at *F*, immediately after the preignition takes place, is in excess of that represented by the area *EFLMIE*, then the crank will be carried over the center, instead of reversing, and the engine will speed up in the forward direction; the full energy represented by the whole area *LMAKL* contributing to give it velocity. Whenever, at an attempted reversal of the engine, this occurs it will, of course, be needless to make a second attempt without first slowing down the engine. If, as assumed, *G* is the point at which reversal of the moving parts takes place, then the area *GHAKG* represents the work available for driving the engine backward. This work must, therefore, exceed by a proper margin the combined resistances existing or occurring during the first backward explosion stroke, during the compression stroke, and perhaps during part of the succeeding explosion stroke, until a new impulse can be obtained.

As the area *GHAKG* will be larger the later the preignition is timed in the compression stroke, with a slow engine speed late preignition is to be considered favorable for sure reversal of the engine. On the other hand, assuming the preignition to be timed early in the compression stroke and the engine speed high, then the compression might readily be carried back close toward the head end of the diagram before reversal takes place, and an ample impulse obtained. Therefore, the preignition must be timed to suit the speed of the engine. A safe compromise will probably be to aim at obtaining the preignition impulse somewhat later than mid-stroke, and to suit the engine speed accordingly. By laying in on the diagram the approximate pressure line *EFG*, and from it estimating the energy represented by the area *EFLMIE*, the maximum allowable engine speed may be approximated, provided the weights of the principal moving engine parts are known.

It may, of course, be necessary to determine, finally, the most effective speed and ignition point by trial, as different engines act somewhat differently, but this will be a simple matter when the conditions underlying the problem have been observed.

In case the ignition is not shifted quickly enough after reversal to time the following explosion near the end of the compression stroke (which in practice is not readily done by hand), then the impulse will be weak. This impulse might occur even as late as at the point *E*, giving for that stroke the small energy represented by the area *EIANE*. The requirements for a sure reversal in this

case will be that the work represented by the combined areas *GHAKG* and *EIANE* must be ample for keeping the engine in motion through practically four strokes.

It is evident, finally, that the smaller the load carried by the engine when being reversed, the more surely it will respond. It is usual, therefore, to unclutch the load before reversal.

With the stated requirements for a prompt reversal of the two-stroke spark-ignited engine in view, it becomes a simple matter to outline the main features that must be embodied in a reversing device which, with one throw of a hand lever, shall automatically reverse the engine. For instance: The throwing over of the lever may be made to effect the closing of the fuel valve and the clutching in of a suitable controller which, when the speed of the engine falls low enough, will open the fuel valve and advance the ignition to the required point in the compression stroke, and, finally, when reversal has taken place, to shift the ignition back to the ordinary running point. The unclutching of the load, of course, must be done as a preliminary operation.

The Bolinders Gear

The features of a reversing device for the two-stroke-cycle oil engine of the hot-chamber fuel-atomizing type would, in principle, be similar to the arrangement just outlined. An example is the Bolinders reversible kerosene marine engine, the reversing features of which are illustrated diagrammatically in Fig. 2. This engine is fitted with two fuel injection pumps, one, *A*, for continuous work ahead or astern, is timed for firing shortly before the head-end center; the other, *B*, for supplying the fuel to produce only the reversing explosion, which is accomplished at the proper point in the compression stroke. The charging strokes of both pumps are regulated on the hit-and-miss principle by an inertia governor. On the rocking bell crank *C*, which is oscillated by the eccentric *D*, are fastened the two small inertia governor weights *E* and *F*, and the cam blocks *G* and *H* are bolted to the sector *K*, which is fulcrumed as shown and free to swing through a small angle.

During uninterrupted work ahead or astern the regular plunger *A* is actuated by the pickblade on the governor weight *E* in the usual way. At excessive speeds the governor weight will hit the shoulder *L* hard and be thrown up out of line with the nose of the pump plunger, thereby causing the fuel charge to be cut out. To reverse the engine from the ahead motion indicated by the arrow in the figure, the reverse lever *M* is thrown over to the astern position, *N*, thereby compressing the coil spring *O*, which presses the arm *P* of the fork on the end of the link *Q* against the shaft. Friction between the shaft and the fork raises the latter and the link *Q* tilts the sector *K* so as to push the pickblade on the weight *E* out of line with the plunger nose of the pump *A*, cutting out this pump; at the same time, the block *H* is moved to the left, allowing the pickblade *F* to be swung by its spring into alignment with the plunger nose of the reversing pump.

As yet, however, the engine speed is too high and the motion of the governor weight *F* too swift to allow the pickblade to act upon the fuel-pump plunger, but as soon as the speed slows down to the proper point, the governor weight will slide easily up on the cam shoulder *S* and the pickblade will engage the nose of the reversing-pump plunger. The opposing charge for the reversal of the engine is thereby injected and fired at the proper point in the compression stroke. The moment the shaft begins to reverse, the sector *K* will drop to its lower position, putting the reversing fuel pump *B* out of service and the regular pump *A* into action. As the engine requires only a few turns for speeding

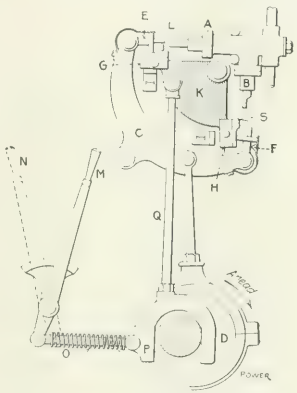


Fig. 2. Bolinders Gear

up, the clutching in of the propeller shaft is done immediately after reversal. The preignition impulse for reversal is somewhat higher than the usual maximum working pressure; a liberal allowance is about 30 per cent. higher. However, as the engine must be built with an allowance for equally heavy casual excess strains, whether it is intended for reversal or not, its weight would not necessarily be materially increased by building it for reversal in the manner described.

Four-stroke Engines

With the four-stroke-cycle engine, the reversing problem becomes somewhat more complicated, because of the necessity that the timing of the valve motion with respect to the crank must be altered. The sequence of the different strokes of the cycle will, of course, be the same whether the engine runs forward or backward; but as plotted on the cam face it will, relative to the one or the other direction of rotation, run in reverse order, due to the reversed rotation of the cam. If, therefore, as may be the most convenient, the compression stroke of the forward rotation be changed into the expansion stroke of the reverse, then the interchange between the strokes becomes:

Forward motion	Reverse motion
Suction	Exhaust
Compression	Expansion
Expansion	Compression
Exhaust	Suction

Normally in carefully adjusted cam motions for four-stroke engines the angles between the center lines of the cams and those of the cam rollers are approximately as follows: With the crank on dead center and ready for the suction stroke, the angle between the center line of the inlet cam throw and the center line through its roller is about 48 deg., and the angle between the center line of the exhaust cam throw and the center line through its roller about 52 deg., the difference between the angles being due to the difference in the most efficient length of the two cam throws. In shifting the cams for reversed motion of the engine, therefore, the inlet cam should be moved ahead 96 deg. and the exhaust cam moved back 104 deg., both counted in the old direction of motion.

Not infrequently, a compromise is made between the differences in the most efficient length of the cam throws, and the same cam is sometimes made to do for both the inlet and the exhaust. In such cases, in order to reverse the motion, both cams should be shifted approximately 100 deg. (for small engines the rule is sometimes to shift them both 90 deg.), the inlet cam being shifted ahead and the exhaust cam backward relative to the previous direction of rotation.

As it would entail some difficulty, however, to shift the cams on the camshaft, this is never done in practice. A simpler way is to mount a second cam on the shaft at the required angle from the regular cam and alongside of it. In reversing, the camshaft is slid bodily lengthwise so as to bring the reverse cam in alignment with the cam roller.

Another method for reversing the timing of the valve openings relative to the crank motion would be to reverse the gear connection between the crankshaft and the camshaft so that the cams always run in the same direction, whether the crankshaft is reversed or not. By this method only one set of cams becomes necessary.

The power for the reversal of the four-stroke engine is always obtained by means of compressed air. In connection with practically all combustion engines of larger power there is required, for starting purposes, an air compressor and

a tank, and the same air supply is used for reversing. The air pressure used is variously of from 120 to 200 lb., but for the sake of better economy, a reducing valve should be inserted in the pipe line between the engine and the air tank. It is imperative for the reliable starting and reversing of the engine that no dead points shall occur during the operation with compressed air, and a sufficient

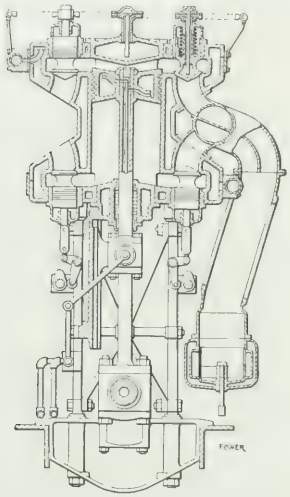


FIG. 3. A "STANDARD" CYLINDER

number of cylinders should therefore be worked by air. The cylinders intended for operation with air are fitted with special air-admission valves actuated by separate starting cams.

In starting or reversing a gas or gasoline engine it is customary, for the more ready handling of the engine by air, to use a reduced compression (about one-half of the regular) in the cylinders operating by combustion. The exhaust valves for these cylinders must, accordingly, be actuated while starting or reversing by special cams that give reduced compression.

THE "STANDARD" MARINE ENGINE

The vertical section through one cylinder of the Standard double-acting six-cylinder marine engine is shown in Fig. 3. The reversing of this engine is effected by means of compressed air which is admitted only beneath the pistons of the three rear cylinders. For the sake of providing against dead points when operating on air, the air-inlet and lower exhaust valves of these cylinders are opened by means of double cams once every revolution of the crankshaft. The opening of all valves is effected by means of a double set of cams; in reversing, the entire camshaft is shifted axially. A small air cylinder and piston are employed for shifting the camshaft and holding it in each position against displacement.

In Fig. 4 is shown the construction of the cams operating the exhaust valves of the upper ends of the cylinders. Both cams and rollers are leveled on their sides, to allow the rollers to slide readily

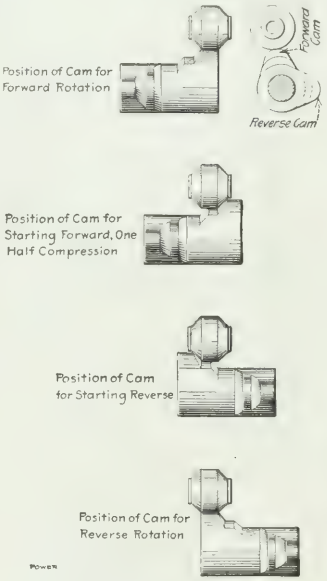

Position of Cam for Forward Rotation
Forward Cam
Reverse Cam
Position of Cam for Starting Forward, One Half Compression
Position of Cam for Starting Reverse
Position of Cam for Reverse Rotation
POWER

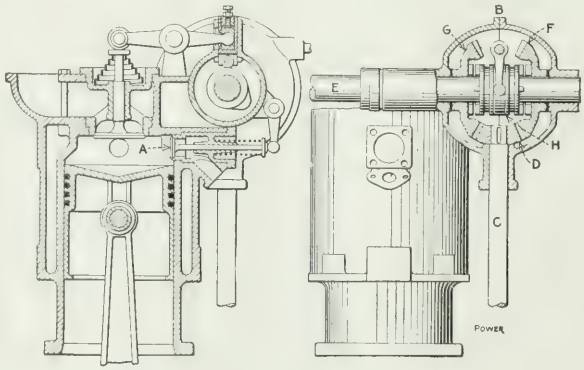
FIG. 4. POSITIONS OF SLIDING CAM

up on the cam throws when the shaft is shifted axially. The cams operating the inlet and lower exhaust valves are of similar construction, somewhat modified to suit the conditions under which they are to work.

For submarine work, the famous Thornycroft firm builds an eight-cylinder single-acting engine the reversing features of which are illustrated in Figs. 5 and 6. Compressed air for starting and reversing is admitted to four of the single-acting cylinders through air valve *A*. There is only one set of valve-operating cams, which rotate always in the same direction, whether the rotation of the crankshaft be forward or reverse. To make this practicable the reversing camshaft gearing *B* is used. The vertical shaft *C* and bevel gear *D* transmit motion from the crankshaft to the camshaft *E*, through gears *F* or *G*. The latter two gears, which are loose on the camshaft, are always in mesh with the driving gear and one or the other is connected to the camshaft by a sliding jaw coupling, *H*, which drives the camshaft by means of a feather and is moved along the shaft by a hand lever.

A SWEDISH REVERSING GEAR

Another reversing gear, which has been adopted by the Sodra Varfs works at Stockholm for relatively small four-cylinder four-stroke-cycle kerosene engines, is illustrated in Fig. 7. Fuel-injection pumps are used, driven by cams on the camshaft. The engine is reversed by means of compressed air which is admitted to all four cylinders in turn, and there are four cams for each of the cylinders, namely, one for the inlet valve, one for the exhaust valve, one for the air valve and one for the fuel admission. These cams are arranged side by side on the shaft *S*. The push-rod which actuates one of the valves is represented at *P* and the cam roller at *R*. The cam roller is not, as usual, connected directly to the valve stem or pump plunger, but mounted on a lever *L*, through which it transmits motion from the cam to the stem or push-rod. For disengaging, in maneuvering, any of the valves or pumps, there is used a control shaft *C*, which carries cams in line with the various cams on the camshaft. If the shaft *C* be turned to the position where none of its cams touch the toes *G* of the levers



FIGS. 5 AND 6. CAMSHAFT REVERSING GEAR

L, then all the stems become inoperative, because the coil springs *Q* will hold the rockers *L* in the position shown by the dotted lines, allowing the main cams to clear the cam rollers *R*. Of the cams

shown on the shaft *C*, *A* belongs to the compressed-air valve, *F* to the fuel-injection pump, and *V* to the inlet and exhaust valves.

In reversing, the maneuvering shaft *C* is first rotated by means of a handwheel so that the point *O* is opposite the toe *G*, and the camshaft *S* is then moved axially so as to bring the reverse cams for the suction and exhaust valves into working position. The control shaft *C* is then rotated further so that the cam *A* comes opposite the toe *G*, in which position the compressed-air valve corresponding to the cam *A* and the inlet and exhaust valves corresponding to the cam *V* will be operative. The air pressure thus admitted will first check the forward motion of the engine and then give it speed in the reverse direction. The shaft *C* is thereupon rotated so that the cam *F* is opposite the toe *G*, causing the compressed air to be cut off and the fuel pump to be put in action.

The Benz Reversing Engine

The Diesel marine engines built by Sulzer Brothers, and those built by the Benz firm at Mannheim, work on the two-stroke cycle, and they are equipped for scavenging purposes with large air pumps driven by cranks on the main crankshaft. The main features of these engines are generally similar to all two-stroke engines of the Diesel type, but the two methods adopted for their reversal may well be worth outlining.

In the Benz engine there are two double-acting scavenging air pumps driven by cranks set at 90 deg. A central extension of the piston of one of these pumps constitutes a compressor plunger for supplying pressure air for reversing and starting and an extension of the other piston forms a second-stage plunger for compressing high-pressure air for fuel injection. The air for reversing and starting purposes is stored at a pressure of 200 lb. in a receiver. The underlying idea of the reversing arrangement is to transform the large pump cylinders, which under ordinary operation supply the scavenging air, into air-motor cylinders or of the reversing of the engine.

The pumps draw, ordinarily, air from the outside and deliver it at a low pressure into a holder which connects and surrounds the air ports of all the combustion chambers. When each piston, at the bottom of the stroke, uncovers these ports, which are cut in the usual way in the lower part of each cylinder, scavenging air is admitted. In maneuvering for reversal, however, the air valves controlling the intake to the pump cylinders are reversed, so that instead of the pistons drawing air from the outside they will receive air from the compressed-air receiver, reduced to about 60 lb., and discharge to the atmosphere, or to the scavenging-air holder. That is, the pump cylinders become changed into air-motor cylinders which resist the forward motion of the engine and finally reverse it.

The scavenging air supply to the combustion chambers is, in the meantime, not cut off, because the discharge from the air cylinders will, in part, be supplied for scavenging. The combustion

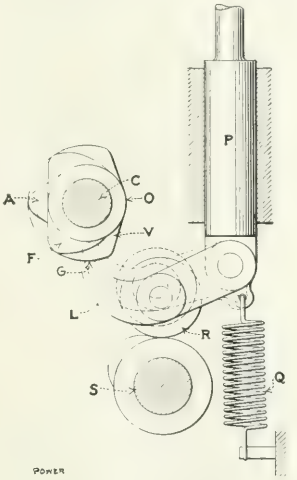


Fig. 7. A Swedish Reversing Gear

cylinders are, therefore, always under normal working conditions and ready to act in harmony with the air cylinders. In reversing, the fuel is, of course, cut off for a short period to allow the engine to slow down, and the timing of the fuel-injection and exhaust valves reversed. The latter is done by the axial shifting of the camshaft, which is fitted with a double set of cams.

Sulzer's Method

For the Sulzer engine the reversing is done by means of compressed air admitted through the regular starting valves directly into all of the working cylinders. A tandem two-stage air compressor, connected to a crank on the main shaft, just forward of the scavenging air pump, supplies the air pressure required for fuel injection and also for starting, the first stage of the compressor delivering to a receiver in which the pressure is kept at about 180 lb., and from which the air for starting and reversing is obtained. The second stage, compressing the air to a very high pressure, supplies the tubes from which air for the fuel injection is drawn.

From the foregoing it is evident that several practical methods are available for making the combustion engine reversible, any one of which, if rightly carried out, ought, especially in heavy marine work, to be preferable to the use of reversing gears or adjustable propeller blades, which at present are the more common methods in use for vessels of small and moderate sizes.

LETTERS

Cost of Fuel for Diesel Engines

In the Mar. 5 issue is an article by R. E. Mathot, entitled "Comparison of Gas, Oil and Steam Motive Powers," in which the Diesel engine is put at a serious disadvantage by reason of the high price of fuel which the author assumed. The price of $1.40 per kilogram, making the operating cost 0.028c. per brake horsepower, might easily be misleading to readers who are not acquainted with the fact that the figures apply only to European conditions—which we presume must be the author's intention.

Fuel oil such as is used in the Diesel engine costs in this country on an average less than one-half of the price stated by Mr. Mathot. Basing the calculations on the consumption of fuel of the respective prime movers as specified in the article, and applying to them actual cost of the respective fuels in this country, will easily show that the Diesel engine offers the lowest operating cost.

Busch-Sulzer Bros.-Diesel Engine Co.,
By A. O. Krieger.

St. Louis, Mo.

[All of Mr. Mathot's figures were based on European practice and conditions and therefore do not give comparisons that are obtainable in the United States. As Mr. Mathot is a well known Belgian engineer, we presumed that these facts would be recognized by our readers. Mr. Krieger's comment on the price of fuel oil is quite warranted.—Editor.]

Pittsburg Greatest Manufacturing District

The total primary horsepower which drives the wheels of Pittsburg, Penn., shops and mills during 1909 was 791,047, according to the industrial census just compiled by Director E. Dana Durand, of the United States Census Bureau, and announced by the Pittsburg Industrial Development Commission.

The figures represent the metropolitan district, an area within a radius of 15 miles of the center of the city embracing many populous communities outside the municipal boundaries. Several of the largest manufacturing establishments are in these suburbs and the statistics of the industrial census make this center the greatest manufacturing district in the United States.

This aggregate horsepower, which is practically sufficient to drive all the big vessels in the navy, is generated in 200 different classes of industries.

The greatest power is generated in the iron and steel works and rolling mills where 54 establishments used 357,945 hp. in 1909, the latest year for which statistics are available in the Federal Census Bureau.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Dust in Relation to Heating*

By Conrad Meier

It is a popular notion that steam and hot-water systems give a different sort of heat. Engineers would define this more correctly by stating that various methods of heating will produce different air conditions. The old-fashioned devices are still considered by many people to be more wholesome, even though less efficient than the modern apparatus, of which it is often said that it does not ventilate, the dead air and stuffiness being attributed generally to the lack of air supply incidental to heating.

Partly out of this idea has grown the popularity of the indirect system, but now complaints are heard, that through heating, and even tempering, by stacks, the air will lose its natural sweetness and refreshing qualities. The recent tendency by the medical profession to oppose plenum ventilation appears to be the result of such observations. Engineers themselves will have observed, especially in public buildings and schools, that even a generous plenum supply will not make the occupants forget the desire to open the windows.

Heated but unoccupied rooms are often found stuffy, even after long vacancy, when natural ventilation, which is always present, should suffice to keep them sweet. Everybody has noticed the stifling air of ill kept, empty railroad coaches which is not altogether caused by overheating, nor by previous occupancy. In such cases the foulness of the air cannot be due to lack of ventilation alone; these circumstances indicate a cause of vitiation aside from the well known sources and explain in a measure the demand for purer air which has really arisen and become general only with the introduction of the modern ways of heating.

None of this evidence is proof that the heating apparatus itself is at fault, but it should certainly raise the question whether the quality of room air is altered in any material way by the process of heating.

Causes of Vitiation

As proof of certain chemical changes there are the investigations of Profs. Esmarch and Nussbaum. The former authority has demonstrated the following points:

Dust, especially when of organic nature, will decompose on heating surfaces from a temperature of about 160 deg. F. upward. Of the gases produced, ammonia is shown by chemical reaction not only over the radiator but in the room air at large. The quantities are usually too small to be called a poison to the average person, but are quite often noticeable by odor. Under extreme conditions, when steam is turned into a dusty radiator or stack, the ammonia may become very disagreeable. Analysis was made for CO_2 but none could be found.

When heating surfaces were carefully cleaned before the test, the effect on the air was still present and demonstrable by analysis, but less intense, thus showing that the dust suspended in the air will also decompose when passing over the heating surfaces, and that there is a constant vitiation going on besides the periodical effect while reheating. No traces of any foreign gases could be detected until steam was turned on; hence it is safe to say that heating is the cause. It may be concluded also, that if heating were accomplished by clean surfaces and without causing air circulation, decomposition could not take place.

Prof. Nussbaum, investigating independently, has arrived at the same general conclusions, but has gone further into certain details. He found that moist organic dust will begin to decompose even at 140 deg. F., while dry dust, or dust in dry air, must be heated to about 200 deg. F. before gases become noticeable. The same applies to dust lying on surfaces or passing by them.

Means to Prevent Vitiation by Heating

Naturally, the foremost remedy that suggests itself is to exclude the dust as the main source of vitiation. All will agree that this would be desirable, but unfortunately it cannot always be done. Even where artificial devices for this purpose are used in connection with warm-air heating and air-supply systems more or less dust will enter into a building in other ways. Vacuum cleaners and general vigilance will help, but the fact remains that a great majority of cases will have to contend with more or less dust.

The safest way to prevent the chemical adulteration of air through decomposing of organic matter would appear to be a moderate temperature of heating surfaces. With clean surfaces and dry air, according to Nussbaum, there will be no vitiation with temperatures up to 160 deg. F., and none to speak of until the surfaces are near the boiling point. Under less ideal conditions, when more or less dust is to be expected, the temperature should be kept down to about 160 deg. F. or lower, as a rule, accepting an occasional rise to 180 deg. F. during a cold spell as unavoidable and of minor importance.

Moderate temperature of heating surface seems also advantageous in view of the devitalizing of the air by the absorption of all the ozone and probably of part of the oxygen.

Hot-water heating would seem to meet the situation best in respect to temperature and liberal surfaces, but whichever system is used, it is advantageous to reduce the tendency to create air currents and to give preference to the kind of surface that is yielding a greater ratio of its heat by radiance. Low and flat radiation which is recommended is generally no more expensive considering its higher total efficiency.

The next important rule should be to insist on clean heating surfaces. It will not do to depend for this on the good intentions of anyone concerned. Engineers must take the first step to induce or compel clean surfaces by selection of the most easily cleanable styles and by proper disposition to keep the greatest part of it in view. As it happens, the styles which are giving the best radiant heat and the least contamination by dust are also the easiest to clean. Radiators should have fair spacing between loops to show the dirt and to make it likely that it will be removed. They should not be tucked away in corners. Better means are always at hand to make them inconspicuous or presentable, as the case may require. Enamel finish in some neutral color, black or white, is only one of those means, which, by the way, will help appreciably in the radiating efficiency. This sort of finish, it is sometimes complained, would show the dust. It is all the more desirable then, in order to induce clean surfaces.

Considering that the requirements for heat and for ventilation generally are not all coincident, and that a purer, more effective and wholesome air supply can be secured by windows or other rational means, when and where required, and without affecting the heat supply, it

*Abstract of paper read before the American Society of Heating and Ventilating Engineers.

would seem that the idea of better sanitary conditions through heating by air is largely a delusion. The indirect method should be restricted to cases where it is really indicated, or, if no other system will do, the conditions might be made more favorable for it by extra protection. In any event, such apparatus should be designed to avoid excessive air temperature, equipped with filters to keep the dust out of air passages and heating stacks, and with all provisions to induce proper maintenance of the apparatus.

The excessive dryness complained of sometimes with direct steam heat is often nothing but irritation of the respiratory tract through dust. It should be relieved in such cases by cleaner radiation and cleaner surroundings, and by lower temperature of heating surfaces. Moistening pans will raise humidity, but generally do not improve the air while dust and dirt are present.

These would seem to be sufficient reasons for reform, and the lines on which to improve heating apparatus from the sanitary point of view do not seem difficult to follow and would lead, if anything, toward greater efficiency in other directions. Nor should there be much difference in cost when taken as a whole. Hot-water heating, for instance, can be brought down very nearly to the cost of steam, if scientifically planned, and the practical possibilities of its adaptation to all sorts of conditions are by no means exhausted. The ways and means for reform may therefore be said to be within reach.

Briefly resuming, the following rules may be put down:

1. To prevent chemical vitiation of room air by heating it is desirable to have heating surfaces at moderate temperature, if possible not exceeding 180 deg. F. at any time and to use easily accessible and clean radiation. Air supply should be filtered where necessary.

2. To prevent the physical admixture of dust and its drying, caused by the air currents due to heating, it is desirable again to use heating surfaces at moderate temperature, well distributed, spread out and inducing salubrity in general.

3. To reduce the pollution of the air by the bacteria the same means are indicated as those recommended to keep down the dust.

4. To produce thermal conditions most agreeable and wholesome to a majority, it seems desirable to favor the application of radiant heat which warms the surroundings and occupants directly and produces comfort at lower air temperature. It should be used in a mild form and be well distributed. Ventilation should be treated as a separate problem, as each can be solved by itself to the best advantage.

5. To prevent excessive dryness, the same idea of keeping down air temperature by utilizing heat rays seems indicated.

6. Ventilating apparatus should be made self-cleaning throughout.

Charge for Steam Heat

Referring to C. E. Diamond's question of a proper charge for steam heat, in the Feb. 27 issue, I had occasion to make a charge for heating about two years ago, and made it on the following basis, which is still carried out:

Each square foot of radiating service will require about ¼ lb. of steam at the boiler per hour. Assuming a loss of 10 per cent. on account of condensation, the actual amount of steam required at the boiler will be 0.277 lb. per square foot per hour. Under good conditions 1 lb. of coal will generate 10 lb. of steam, and on this basis there will then be required 0.0277 lb. of coal per square foot of radiating service per hour. From the number of square feet of radiation supplied, the total coal required can then easily be determined and the charges based on the cost of the coal per ton.

The cost of operating the plant to give the above condition will simply be in the same ratio as the amount of coal used for heating to the total amount of coal used in the plant. For example, if the heating service requires 10 per cent. of the total coal burned, the charge would be 10 per cent. of the coal bill plus 10 per cent. of the other operating costs in the plant. There will, of course, be some variation due to extreme cold and mild weather, but the above will give a fair average.

If more exact conditions must prevail, it might be advantageous to install steam meters and base the charges on the percentage of steam used for heating to the total amount of water evaporated in the plant.

W. R. METZ.

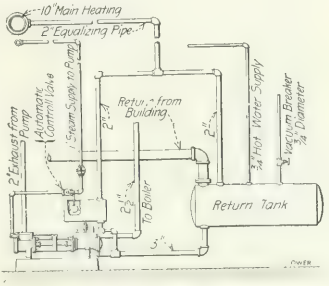
Washington, D. C.

Why Does This Pump Race?

I am employed in a steam-heating plant, the heating being done by three return-tubular boilers, 66 in. by 18 ft., through a two-pipe, direct, dry-return system. The building is seven stories high. The returns empty into a tank 6 ft. long and 2 ft. in diameter, and from there are pumped back to the boiler by a Deane duplex pump, 7½ and 4½ by 12 in. The pump is automatically controlled by the height of the water in the tank: when the tank is half full the pump will stop and as the water rises it will go to work again.

Held up from the floor by a support, to the height of the top of the discharge chamber of the pump, is an equalizing tank. The steam-supply pipe comes down and rests on the top of this tank. At this point there is a steam valve in the pipe that is connected to a rod running down into the equalizing tank. To this rod is attached a ball float, and there is a ball and lever connected to the top of the valve. The height of the water in the equalizing tank corresponds to the height of the water in the return tank; so that any variation of water level will cause the steam valve to open or close. An equalizing pipe from the steam main is connected to and has free opening to both the equalizing and return tank. The water supply to the pump from the return tank is piped to the suction chamber and just outside the chamber this pipe is tapped and a branch run to the bottom of the equalizing tank. The pump discharge is piped direct to the boilers. There is a pipe leading from a hot-water tank to the return tank for the purpose of increasing the supply to be pumped to the boilers. A vacuum breaker, operated by opening or closing a valve, is placed on the top of the return tank.

These boilers carry 80 lb. steam pressure, and the pressure on the heating system is 4 lb.



PIPING TO PUMP AND RETURN TANK

Now when the steam heat is shut off and the vacuum breaker opened, the pump, instead of working along as it has been doing, will suddenly begin to race, starting slowly and speeding up, and if let alone would tear itself to pieces. At the end of the stroke there is a violent noise. I shut the pump down and wait until all escaping steam and air have stopped at the vacuum breaker; then I start the pump and no more trouble is encountered until the next time.

The man who installed this plant says it cannot be run without the equalizing feature, but with this feature cut in or out it makes no difference in the action of the pump. It may be that some of the readers of POWER have had a similar experience and can give an explanation.

W. T. MOULTON.

Portland, Maine.

Belgium produced 23,125,200 tons of coal last year, but it had to import between three and four million tons.

Stereophagus Sewage Pump

This pump, which is of the centrifugal type, has been designed for pumping sewage water. It is manufactured by R. C. Parsons, 39 Victoria St., London, S. W., England.

In Figs. 1, 2, 3 and 4 is illustrated the construction of the interior of the pump and the impeller, which is made conical. The liquid is admitted to the impeller on one side only. There is also but one side or shrouding to the impeller from which the blades project, their edges terminating in a conical shape.

Surrounding the impeller is a spiral chamber leading to the outlet pipe, similar to the ordinary centrifugal pump. Attached to the interior of the inlet pipe, and projecting as far as the center is a fin having its upstream edge sloping gradually to the side of the pipe, as shown at *A*, Fig. 3. The casing on the conical side of the impeller is formed to the same angle as that of the impeller, so that the edges of the blades fit against the internal surface.

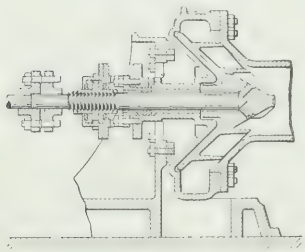


FIG. 1. SECTIONAL VIEW OF PUMP

FIG. 2. LOOKING INTO THE CASING

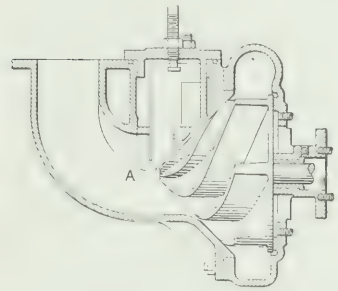


FIG. 3. SHOWING SLICING KNIFE

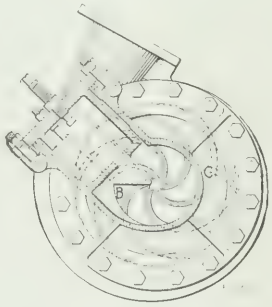


FIG. 4. CASING FROM THE KNIFE SIDE

At the side of this casing is a cylindrical chamber, in which is a holder containing a steel knife with a sloping edge so as to coincide with the angle of the blades of the impeller, as shown at *B*, Fig. 4.

The upstream side of this knife is in line with the fin and its point reaches to the center of the impeller. In the conical surface of the casting is a spiral groove having square edges, as shown at *C*.

The action of the pump is as follows: Having been charged and set in motion, it draws the liquid in through the suction pipe which passes between the blades of the impeller into the spiral chamber and is injected to the delivery pipe. Should there be any solid materials in the liquid, they slide along the fin and, coming in contact with the blades of the impeller, are carried around until they reach the edge of the knife and are cut to pieces. Should they not be cut small enough to pass through the passage between the blades the first time, they are carried around and are recut as often as required to enable them to pass through the impeller.

The passages between the blades of the impeller at the point where the cutting takes place are arranged to be of the least dimensions of any of those in the pump and to enlarge therefrom toward the outlet, so that no piece of solid substance which passes the knife can become fixed in any of the passages.

In the event of any substance becoming jammed between the edges of the blades of the impeller and the casing, they fall into the spiral grooves in the face of the conical casing and are ejected with the fluid that is being pumped. The cutting action of the impeller blades as they pass the knife is at one point at a time, and therefore no perceptible shock occurs when any substance is cut up.

Means have been provided for adjusting the impeller toward the conical casing and as the edges of the blades become worn they are brought closer.

Vulcan Automatic Drain Valve

A device used in conjunction with the Vulcan soot cleaner is an automatic drain valve, as shown in Fig. 1. It can be used for other purposes. G. L. Simonds & Co., 64 East Van Buren St., Chicago, Ill., are the manufacturers.

This valve is to prevent water getting into the piping due to leaks which might occur in the operating valves, discharges any water that might get past a leaky valve and also indicates such leakage.

It is a gravity check valve and is placed just beyond and below the operating valve on the no-pressure side, being set vertically and connected to the main horizontal line overhead by means of a nipple and return bend, as shown in Fig. 2.

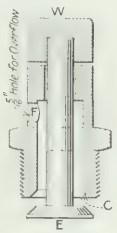


FIG. 1. SECTION THROUGH VALVE

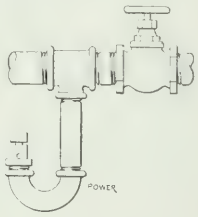


FIG. 2. APPLICATION OF VALVE

The valve is made of brass and consists of an outside casting threaded at the bottom as shown. The bottom of the valve chamber is finished off in the form of a valve seat at *C*. The disk *E* is thrust upward when the steam pressure is turned on, thus making the escape of live steam impossible. The instant the pressure is released, the combined weight of the disk, valve stem, and weight *W* causes the disk *E* to drop, thus leaving a free vent through the opening *F*.

Any steam or condensation leaking through the globe valve in Fig. 2, cannot get into the piping system as the water would drop down the return bend and flow out through the opening in the drain valve.

Recently a collier at the coal pier of the Baltimore & Ohio R.R., in Baltimore, was loaded with 7029 tons of cargo coal and 545 tons of bunker coal in 4 hr. 30 min., thereby establishing a record in coal-handling.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 28,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Cleanliness in the Power Station

Cleanliness and system are two of the prime requisites that make for satisfactory operation in the electric power station. They cannot be too strongly emphasized, and if they are not rigidly observed, the best installation will fail of its purpose and the money expended on it will, to a great extent, be wasted. Every piece of the equipment should be kept neat and clean and its installation so arranged as to permit of this being easily accomplished. For example, the switchboard and controlling apparatus should be placed out from the wall a distance sufficient to allow the operator to get behind them easily and this space should be kept free from all material not directly connected with the operation of such apparatus. That this is not always done is only too true, as a casual glance behind many a switchboard or machine will testify.

The use of switches and wires as hangers for articles of clothing, etc., is a practice sometimes seen and one that should never be allowed; metal lockers, well ventilated and of sightly appearance, are a necessary adjunct to a properly equipped power house. Individual metal receptacles provided with hinged metal covers or lids for the accommodation of oily waste or waste papers should also be considered necessary parts of the equipment. Such things as these are potent factors in the reduction of fire risks.

The power station should not be used as a storage place for spare parts and for the storage and filtering of oil; where possible, a separate building should be used for such purposes. A power station large enough to contain a miscellaneous lot of material that might be stored in it is too large for the real purpose for which it was built, which usually means that more money was expended on its erection than was necessary. It is considerably cheaper to build storage houses than power houses.

The windows should receive sufficient attention to keep them in efficient condition and if any are located near electrical apparatus they should be so arranged that they can be closed quickly and easily to prevent any damage that might result from rain beating in. It is also well to have all lamps, as far as practicable, so located as to be accessible for trimming or cleaning from the floor, platform, walks, etc. It is usually found that in the best lighted stations the lamps are thus arranged, for the easier it is to care for them, the better attention they will get.

A fire hose conveniently located and an easy connection to a water main have been found a very profitable investment; in addition to this, a few buckets or boxes of dry sand and a fire extinguisher or two will be found highly advantageous in case of fire in a part of the plant where water cannot be applied.

It may be possible that some of the foregoing suggestions will seem quite extravagant and their adoption to entail unnecessary expense and trouble; nevertheless, their strict observance will result in more pleasant surroundings for the men in the station, far less risk of fire, lower insurance rates and less liability to service interruptions.

A clean and well ordered power house is indicative of smooth running, well kept machinery and, consequently, a low operating cost, which is, after all, the main object for which the engineer should strive.

Using Second Hand Machinery

Frequently there are cases where apparatus has been shipped for installation that was defective in some of its parts; perhaps the exterior presented a finished appearance, but some detail of interior construction may have prevented proper operation.

The small boy is expected to take apart almost anything that falls into his hands because he wants to know how it is made.

but it is not advisable for an engineer to disassemble machines which arrive at the plant for installation; he should make sure, so far as it is possible, that they have been properly assembled and are in good condition.

This is especially true in the case of large concerns where the machines in one plant may be discarded for a time and then installed in another for permanent use.

A case has just come to light where a motor-driven centrifugal pump was to be used as a boiler feeder. When the pump arrived the engineer figured that it was capable of delivering water against a pressure of but twenty-three pounds. He was assured, however, that it was good for sixty pounds pressure; and the pump was installed. After it was tested out, the best to be obtained was a delivery pressure of twenty-one pounds. Of course, the work of installing and dismantling was a dead loss, as well as the service of the pump. Either carelessness was responsible for this blunder, or else it was a case of "put it in and see what it will do." Such practice is not advisable in power plants and is usually disadvantageous to all concerned.

A duplex steam pump was next delivered to the plant, the connections were made and the steam was turned on, but the pump refused to move. An examination showed that the pistons were so badly rusted in the cylinders that it was necessary to use a hammer and a block to loosen them, and the pump was badly corroded in the steam chest and other interior parts. The pump was made to run after considerable trouble, but it would not deliver sufficient water.

Another pump was installed and before it had been in operation an hour the piston came off the rod and the pump was shut down for repairs. When it came back from the shop the engineer found that the threads on the plunger piston were of a special size and that a nut one size too large had been used. The locknut had been omitted, and if the pump had been started there probably would have been another accident.

These are little matters, but they go to show that someone must have been careless.

Second-hand machinery may answer in some places, but the power plant is not an ideal place for trying them out. It would doubtless be money well invested if such apparatus were tested out before being delivered for installation; certainly this would avoid useless work and costly delays in many cases.

Prepare for the Summer Now

As summer is approaching, with its hot, sultry days—days when the engineer's labor should be as light as possible—preparation should be made to care for those small things which, individually considered, are of little importance, but which collectively promote comfort and facilitate the operation of the plant.

Perhaps there are leaky flanges and fittings with sand holes in them through which steam hisses the announcement of a remediable loss. The steam headers on top of the boilers with their many branching lines may be the source of erosion and damage to brickwork by reason of the constant dripping of water of condensation. To change over from one header to another in a large plant is not a pleasant task; many valves, usually stiff and difficult to turn, must be opened and closed, and this is much less arduous while the weather is cool than in midsummer; much trouble and inconvenience may be avoided by "doing it now."

In the cellars and tunnels like conditions may prevail. Work in such hot, close quarters may be much more comfortably undertaken at this season, especially as it has to be performed in a short time in order to prevent any interruption of the service during a period when service is needed most.

It may be that the bridge-walls and arches require patching, or sections of the grate bars need renewing and the boilers cleaning. Perhaps the soot pits, breechings and chimney base are full of soot, and thereby seriously interfere with the draft and the boiler economy.

The feed-water filters surely will better perform their function if they are cleaned and the filtering medium is renewed. Warm weather increases the demands on the refrigeration plant, and to meet them the plant must be in good order.

It is very probable that the coal-handling machinery is worn, and the belt housing contains fine, hard-packed coal which prevents the guide pulleys from working freely.

Now is the time to make an effort to systematize work that is so essential to the safe and efficient operation of the plant; much can be done thoroughly and comfortably at this season which if neglected until the hot summer days would be slighted or left undone.

Load Factor

Engineering practice seems to be handicapped in many respects by a lack of definite standards by which the performance of similar installations and apparatus may be readily compared. Important among these is "load factor," which term is interpreted in so many ways that much unnecessary confusion results.

A prominent engineer (presumably an expert in his line) was asked upon the witness stand recently to define what is meant by "load factor." He replied that any one of several answers might be made, each equally correct according to the interpretation of the conditions. He stated further that he had a conception of what should properly be designated as the load factor, but any other engineer holding a different opinion would be equally justified in the light of present practice.

This witness summed up the situation very clearly and concisely. By many the term "load factor" is used to mean the ratio of the total yearly output in kilowatt-hours or horsepower-hours to the rated yearly capacity in similar units. Others regard it as the ratio of the output to the maximum continuous capacity; while still another group of engineers, notably in English practice, consider the load factor as the ratio of the average load to the maximum load carried at any time during the year.

The first of these methods might seem a rational basis provided all similar machines were rated according to the same standard, but unfortunately the practices of manufacturers also differ in this respect. However, we shall not attempt to go into the merits or demerits of any of the methods mentioned, but merely wish to call attention to the need of some definite basis being selected and observed. Since the cost per kilowatt-hour is directly dependent upon the load factor, the selling price is often similarly determined; hence the importance of formulating a definite basis

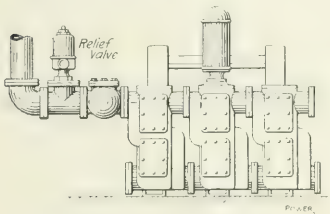
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Mine Pump Gasket Blew Out

An experience I once had with a 6x8-in. triplex power pump, driven by a 50-hp. motor, and located at the bottom of a 500-ft. shaft, may be of interest to mine engineers.

To place the pump it was necessary to take it to pieces, and reassemble it in the mine. In so doing, the bolts that hold the cylinders to the base probably were not drawn up evenly, for on starting up the gasket blew out. A new gasket was cut from common red sheet packing, and the pump started, but this gasket lasted only a few minutes.



RELIEF VALVE ON DISCHARGE PIPE

The sump was filling fast and something had to be done quickly. As I was out in the country I had to use what material I had on hand. A new gasket was cut from the same sheet packing; a wire fly screen was taken from a window and a gasket cut from that and placed on the top of the sheet rubber, and the pump started, but not before the water was up to my knees. That gasket has been in use for six months and is still tight, although another one ordered from the pump factory is in readiness if needed.

This pump is at the bottom of a 500-ft. shaft and the discharge pipe has no stop valve. A gage at the pump registers 230 lb. per square inch. Twice the pressure has burst the tube in a 300-lb. gage and once cracked an air chamber. As there can be no pressure in excess of the head, I was at a loss to account for what was very evidently an increase in pressure at times. I finally decided that it was due to water-hammer caused by the pump being allowed to run after the sump was empty.

As the pump sucked air, and the water surged, in the vertical discharge pipe, I put a check and a relief valve in the pipe as shown, and have had no trouble since.

E. J. SAXE.

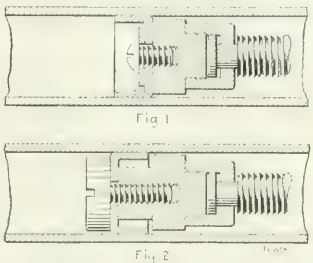
Christopher, Ill.

Calibrating Gages

Most progressive engineers have the conventional screw force pump for comparing pressure gages. This pump, with slight modification, is also useful for comparing vacuum gages. The one I use has a bore of 1⅛ in. and the plunger is arranged as shown in Fig. 1 for testing pressure gages.

It is also an excellent and simple device that can be easily reversed by turning the leather around, fitting a new screw and washer to look as shown in Fig. 2.

Care must be taken in filling the pump with water to have the pipes full and the plunger just covered. After a few trials one will become expert in obtaining 22 in. or more of vacuum. Then correct the faulty vacuum gage by resetting the index.



SECTIONAL VIEWS OF PRESSURE-PUMP PISTONS

FRANK MARTIN.

College Point, N. Y.

Cleaning Air Compressor Cylinders

For cleaning air-compressor cylinders I tap a ½-in. hole in the suction line near the cylinder and screw in ½-in. pipe. Running vertically from this is a 2-in. pipe, 18 in. long; on top of it I put a screw cap and on the ½-in. line I put a globe valve.

Once a week I use 2 gal. of hot water in which has been sliced a cake of soap. I stir it thoroughly until all of the soap dissolves; then gradually pour in the top of the pipe, through a screened funnel, using about a cupful at a time. After using about three-quarters of the suds, I pour in one-half a cup of oil, and wash out with the balance of the suds. The oil is then put in at the suction inlet, so as to lubricate both upper and lower parts of the cylinder; when oiling with lubricators the oil does not get to the bottom of the cylinders.

Where there are two cylinders, of course the piping is also attached to the low-pressure one.

A. P. SHAW.

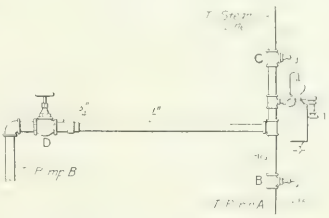
Lima, Ohio.

Why Won't the Lubricator Work?

I have a lubricator puzzle which I would like to have some reader of POWER solve for me.

I installed an extra boiler-feed pump a short time ago and, not wishing to buy an extra lubricator, I piped the steam so that one lubricator and throttle valve answered for both pumps. I placed a valve *B* and *D* in each pipe between the pumps and throttle valve *C*, as shown.

The pump *A* is used regularly and after starting it up I found that the lubricator would not operate and, thinking it might be stopped up, removed it and gave it a thorough cleaning. It balked just the same, so I put on another and it acted in the same way. As a last resort, I removed the valve *B* and the lubricator works satisfactorily. I tried to operate the lubricator with the valve *C* wide open and using the valve *B* as a throttle valve, but the lubricator acted the same.



LUBRICATOR AND PIPE CONNECTIONS

When using the pump *B* with the ¾-in. valve *D* open wide and using *C* as a throttle, the lubricator works all right.

Now, why will it not work with the valve *B* open and using the valve *C* as a throttle?

The pump *A* has a detachable valve rod, so I can lift it off and stop the pump when I wish to run the pump *B*. I am going to put a ½-in. stop cock where I had the valve *B* and see if it will help any, as I want a valve at that point.

W. S. HULL.

Sheldon, Ill.

Riveting on Saddle Flanges

Owing to the installation of a new engine and condenser, it was necessary to make some changes in the discharge line which served two other condensers. These could only be shut down for about two hours each day. Owing to the elevation of the discharge line, it stood full of water when not in use; hence it would have to be drained and dammed up each night.

As one of the jobs was putting a 30-in. saddle flange on the under side of the 36-in. end of the discharge line, to get a siphon effect, the job would require considerable time, as the bolt-holes would have to be drilled, the 30-in. piece drilled out and several 30-in. fittings placed before the valve was put on.

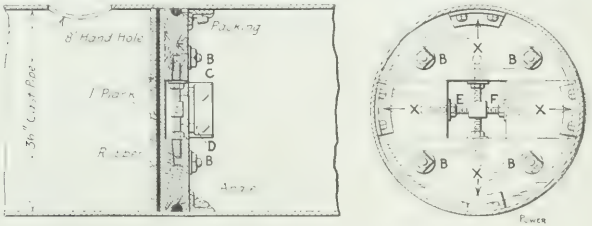


FIG. 1. SIDE AND FRONT VIEW OF BULKHEAD

The bulkhead shown in Fig. 1 was used, which is almost self-explanatory. A 20-in. manhole was already provided on the top side of the line. The small hole near the bulkhead was cut, through which tools were passed, and to serve as a means of ventilation. The bulkhead was made in four pieces, so mortised that the pieces would slide one upon the other.

The bolts *B* were to be tightened up after the pieces were shoved hard against the wall of the pipe by the jacking screws *C, D, E* and *F*. The holes through which the bolts *B* passed were made large to allow the proper movement of the bulkhead, and were countersunk on one side to allow two thicknesses of 1-in. boards to be nailed, sheet rubber being placed between them.

A groove was cut around the circumference of the head in which packing, rubber or oakum was placed before the head was tightened. The holes were drilled deep enough so that the studs *C, D, E* and *F* could be dropped in while assembling the pieces, when they are screwed into the common center piece, the nuts backed down against the washers and the head tightened.

Nominally, this bulkhead had only a 3-ft. head of water on it, but during a heavy rain it would be as high as 10 ft., owing to back water from a city sewer. It was in place for about three weeks and did not leak. At the same time it was found that another connection would have to be made to a 48-in. supply main, which had a 12-ft. head of water in it.

As in the discharge line, the connection was to consist of a 30-in. saddle flange and 30 ft. of pipe and fittings, and the same conditions were imposed; that is, the line could only be worked on about three hours each night, and it would have to be drained each time, this meaning the draining of 1100 ft. of 48-in. pipe.

Another condition was that there were three engines served from the end of this pipe, and as the flange was to be placed ahead of the condenser connections, some method had to be devised to work on the line and yet not shut the water off of the end of the line.

In Fig. 2 is shown how the job was done. This sketch is self-explanatory; the only thing to look after is to see that the bridge *G* consists of a good piece of wood and arched out over the proposed hole, to allow for putting in the bolts or rivets. The pieces were put in through a 20-in. manhole and assembled inside.

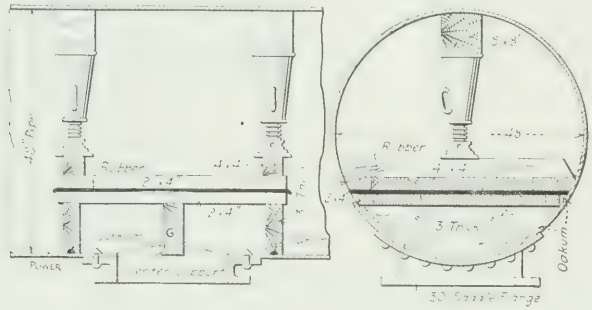


FIG. 2. ANOTHER METHOD OF APPLYING BULKHEAD

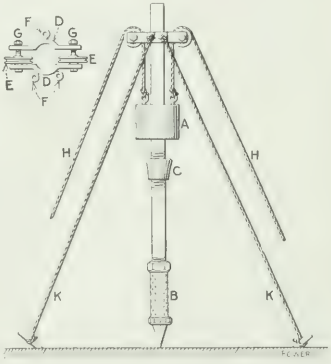
EDWARD H. LANE.

Kansas City, Mo.

Rigging for Driving Small Pipe Well

The engineer is sometimes called upon to drive small pipe wells, and the usual way is to rig up a platform of some sort upon which one or two men can stand and drive the pipe down by means of heavy mauls, but this method is slow and expensive in comparison with the plan that I once saw adopted.

The pipe was cut in short lengths, so as not to have to raise the weight *A*, shown in the illustration, too far from the ground at the start. The drive point *B* was screwed on to the end of a piece of pipe which was coupled to a second piece by means of the special coupling *C*. The weight was then placed in position against the coupling. Then the clamp *D*, which carried the sheaves *EE* and eye-bolt *F*, was placed on the upper end of the pipe, as shown, and held in place by the bolts *GG*.



PIPE-WELL DRILL

The two ropes *HH* were then passed around the sheave wheels and secured to the eye-bolts in the top of the weight, as shown. The whole was then raised to a vertical position by means of the guy lines *K*, which were secured to stakes driven in the ground.

The weight *A* was raised and let drop by two men pulling and letting out on the ropes *HH*. The pipe is kept plumb, by taking up on the guy lines.

A tripod can also be used in place of the guy lines, with a guide at the top in which the pipe can slide. The weight should weigh from 200 to 300 lb., according to the size of the pipe.

GEORGE J. LITTLE.

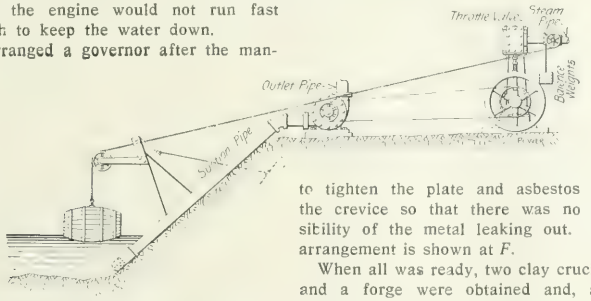
Passaic, N. J.

Barrel Engine Governor

I took charge of a pumping plant at a cement works, and in order to get the marl for making the cement it was necessary to pump the water continually from a large lake so that the men could shovel the marl from the bottom. Owing to the many springs it was necessary to pump 24 hours a day and seven days a week.

I had a belt-driven rotary pump driven by a 20-hp. slide-valve engine. Because of the variation in the amount of water supplied by the springs, and to the engine having no governors, I had trouble in controlling the speed. Sometimes it would drain all the water out of the hole. The pump would then lose its priming and the engine would race. At other times, the engine would not run fast enough to keep the water down.

I arranged a governor after the manner shown in the illustration. It is made out of an ordinary oil barrel with the bung hole plugged. I then secured a light cable to the barrel and ran it over a grooved pulley which was supported by a frame. The other end of the cable ran to the throttle of the engine, on which I fixed another grooved pulley. The cable was wound around this wheel a couple of turns and a weight to counterbalance the barrel was attached to the loose end of the cable.



BARREL FLOAT GOVERNED THE ENGINE SPEED

The device worked finely and was the means of ending my troubles.

J. R. HARDISTY.

Paris, Ont., Can.

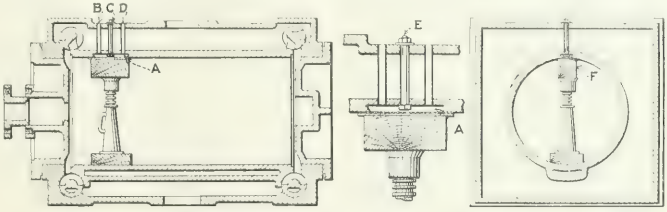
Patching a Corliss Cylinder

Some time ago I had occasion to overhaul a large Corliss engine, and found a deep grove about 2 in. wide and 12 in. long in the top of the cylinder and about 1 ft. from the crank head, as shown at *A* in the illustration.

I finally concluded that a copper patch would be the most durable and best from all standpoints. The groove was squared and chipped and the edges dovetailed, making a slot 2½ in. wide, 12¾ in. long and ⅞ in. deep. I then took a ratchet and drilled three holes, *B*, *C* and *D*, through the top of the cylinder wall and the top of the steam chest. In each of these holes I tightly fitted a piece of ½-in. pipe just long enough to come even with the top of the steam chest and in the cylinder wall even with the bottom of the groove.

A bolt with a square, flat head *E* was made and suspended by the nut and a washer through the pipe in the hole *C* and served as an additional anchor to the dovetail to hold the patch in place. A piece of heavy asbestos paper large enough to more than cover the patch all around was obtained, also a piece of sheet steel of the same size. These were bent to the circumference of the cylinder. Next, a block the same size as the piece of steel was trimmed so as to conform to the same circle. A jack screw, with a block underneath, was used to tighten the plate and asbestos over the crevice so that there was no possibility of the metal leaking out. This arrangement is shown at *F*.

When all was ready, two clay crucibles and a forge were obtained and, after constructing a temporary furnace out of firebrick around the forge, the copper was melted; and, using the hole *B* to pour through and hole *D* as a vent, a good job was obtained. A heavy air hammer was then used to peen the surface of the patch until it was nearly flush with the surrounding surface of the cylinder. It was then scraped smooth.



METHOD OF REPAIRING A SCORED CYLINDER

The melted copper filled each of the pipes *B*, *C* and *D*. It was peened over in the case of the pipes in the holes *B* and *D* and the nut and washer on the bolt took care of the hole *C*.

Many engineers asked me why we did not rebore and bush the cylinder, but it is evident that this would be impracticable, as it would have required a bushing ⅞ or 1 in. thick, together with the necessary time and expense to do the job.

Several mechanics argued that the copper patch should have been peened in in sheets or laminations in order to get a good, tight job, but I concluded that the melted copper would come nearer finding all of the uneven places, and it did.

THOMAS M. STERLING.

Middlebranch, Ohio.

A Troublesome Feed Pump

Some time ago I was called in to examine a feed pump of a neighboring plant which the engineer in charge had been unable to operate satisfactorily. The pump was connected up in the ordinary manner with a globe and check valve next to the boiler and the pump would be operating nicely but at times would not force water into the boiler.

I shut the pump down and soon found that the gasket under the valve plate did not extend across the center rib and both ends of the pump were connected through the opening left under the valve-seat plate. This was remedied and I supposed that I had overcome the trouble, but I found that I had patted myself on the back too soon.

When the pump was started up it ran nicely for a time and then failed to deliver water to the boiler. The cylinder head on the water end was then removed and the plunger repacked. When the pump was again started it pumped water, but later on would not supply a sufficient amount to the boiler.

This "off-again-on-again" action was puzzling, and as no defect in the pump could be found a machinist was called in, but without results. Finally an injector was piped up, in order that the plant could operate while the pump was being given a thorough overhauling, and to my surprise the injector failed to operate.

This was clue enough, however, to the probable cause of the trouble. The cap of the check valve was removed, but it was in good condition; then the globe-valve bonnet was taken off, and it was found that the disk had come off the stem and rested upon the seat, effectually preventing the free admission of water to the boiler.

Just why the disk shifted enough to allow the pump to feed the boiler at one time and then changed again and cut off the water is a matter that has puzzled all concerned.

A. J. BERLIN.

Veedersburg, Ind.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Laying a Plant Up

Replying to Mr. Goal's article, "Starting a Plant Shut Down for a Year," in the issue of Feb. 13, I would suggest when a plant is to be shut down for six months or a year, that all the manhole and handhole plates be taken off the boilers, and all the joints on the boilers and plates be cleaned and covered with heavy oil or hard grease and the boilers thoroughly cleaned.

An outside inspection of the brickwork should also be made, and if any brickwork or resetting be necessary, it should be done at once, to allow time for setting and drying thoroughly, as brickwork is apt to crack if not thoroughly dry when fire is started in the furnace. All valves should be opened wide and then turned back one turn to keep them from sticking. Be sure there are no pockets for water to stand in, freeze and cause trouble.

The water glasses should be taken out so that new rubber gaskets will be put in when starting up as the old rubber will get hard and crack.

The feed pumps should have all the packing taken out of the piston and valve rods, and the stuffing-boxes should be filled with clean waste soaked in cylinder oil; take out the valves, clean and give them a coat of hard grease or cylinder oil, and be sure to leave no water standing in the pumps. The feed-water heater should also be cleaned out.

The engines should be laid up before the boilers; have a light fire in the furnace and very little steam pressure, then the packing can be blown out from around the pistons and valve rods. After this cut the steam off at the boilers and open all valves on the steam lines and engines. This will leave the engine and pipes hot to dry out. When the engin is cold, take off the cylinder head and steam-chest cover; also take out the valves and give the interior of the cylinder, the steam chest and the valves a coat of heavy cylinder oil. This will keep them from rusting. Fill the stuffing-boxes and the pumps with waste and cylinder oil. All bright work should be slushed with grease or heavy oil.

If the plant is in a building which is to be closed up, there should be some means for the air to circulate in the building; if not, the machinery will sweat in the change of temperature from summer to winter. If the smokestack is of iron, it should be covered.

GEORGE L. BAILEY.

New York City.

Taking Charge of a Plant

The article starting up a plant in the Feb. 13 issue, by Mr. Goal deserves some comment. An engineer should take nearly all of the precautions mentioned on first taking charge of a plant, even though it has not been shut down. He should enter the boiler at the earliest opportunity and learn its condition, examine the brickwork and repair it if necessary, replace the defective grate bars, and be sure the steam gage and safety valve are in proper condition.

Standing a year may have loosened some scale and permitted some rust to accumulate, but it would not change the position of the feed pipe or the water column, nor fill the heater with scale or change the setting of the engine valve. A plant closed down yesterday may be in as bad a condition as one of a year ago.

If an engineer knows that the man who formerly had charge was careful and intelligent, he may take a little more time before giving the plant a thorough inspection, but he must know for himself the condition of the steam gage and water column, that the pipes leading to the water column are not clogged, and he will learn about the grate bars the first time he throws coal into the furnace. In short, an engineer should never take things for granted.

G. E. MILES.

La Jara, Colo.

Home Made Damper Regulator

Martin McGerry's damper regulator, as shown in the issue of Feb. 13, is out of true or incomplete.

It can readily be seen from his sketch how the damper can close; in fact, by all the known laws of nature it should have been shown closed; but how it is to open again is a mystery which Mr. McGerry neglected to explain.

If the long pipe, shown as coming from the boiler, entered the top of the cylinder, and the drip pipe entered the bottom, and a steam-tight piston was used instead of the leather cup on the plunger-rod, the device might be made to open and close the damper in a more or less satisfactory manner.

As a rule, I think that home-made damper regulators are unsatisfactory, and that the closeness of regulation and the dependence which can be placed on the operation of the many familiar makes of regulators on the market will amply repay the comparatively small cost of securing one of them.

JOSEPH KING.

Lynn, Mass.

Changes Necessary

The defects of Mr. Gillmore's diagrams shown on page 235 in the Feb. 13 issue can be remedied in the following way:

The governor should be advanced to give earlier admission, as it cannot be done by changing the rods without interfering with the speed regulation. In order to find the amount of advance, turn the engine to the crank-end center, take up all the lost motion in the eccentric straps and rod heads, remove the bonnet from the crank-end steam valve, that the port marks on the valve and the valve seat can be seen, and note the position of the valve. It should have ¼ in. opening or lead.

There is a chisel mark on the hub of the eccentric which should be in line with one on the boss of the governor wheel. If it is not, the two setscrews, acting as stops for the governor crossheads, have to be adjusted. Next loosen the governor springs and throw the weights out, making sure that the eccentric moves to the mark, which denotes its position of least travel.

The valve should lap the port now $\frac{3}{32}$ in. The motion of the valve, due to the change of the eccentric from greatest to least stroke, should therefore be $\frac{3}{32}$ in. for engines up to 18x24 in. The larger sizes require $\frac{5}{32}$-in. lead and the valve motion must be $\frac{7}{8}$ in. If this motion is less, as it seems to be in Mr. Gillmore's engine, the governor must be turned in the direction of rotation until the required lead and lap can be obtained.

An offset key will be necessary. The head-end admission valve must also be looked over while the crank is on the head-end center. The valve motion will be a little greater on this end, owing to the angularity of the eccentric rod, and the position of the eccentric pivot pin.

The right-hand diagram shows that steam leaks into the cylinder after cutoff.

The valve and valve seat should be examined and fitted to a bearing. The compression is late for this style of engine, especially in the left-hand diagram, where the release is also late.

The exhaust valves should close for compression when the crosshead is one-sixth of its travel from the end of the exhaust stroke and open for release when it is one-twelfth from the end of the steam stroke.

M. WERNER.

Chicago, Ill.

I would like to submit the following to J. D. Gilmore, who showed some diagrams in the Feb. 13 issue. Both diagrams show late admission, and the left-hand one shows little or no compression.

As the remedy, I would adjust the steam rods so as to give the valves more lead until the admission line is vertical; adjust the exhaust rods to close the exhaust valve earlier in the case of the left-hand diagram.

J. P. COLTON.

Ohio City, Ohio.

Water Gage Illuminator

Mr. Lehman's letter under the above heading in the Feb. 6 number is interesting. It shows that he has put some thought into the matter. But, will Mr. Lehman tell us what he is going to do with that mirror after the glass lets go?

A little cleanliness is the only condition I ever thought necessary for the easy reading of any water glass that I ever saw.

WILLIAM E. DIXON.

Malden, Mass.

Christie Air Steam Engine

In the Jan. 30 issue, Fred Boone makes several mistakes. He says that if air diffuses from the engine cylinder into the boiler, the diffusion through the inlet valve of a gas engine would fill the engine room with dangerous vapors. He neglects the difference in pressure of the gases in the two cases. The steam-engine cylinder is open to the boiler when the air is under from 75 to 150 lb. pressure per square inch, but the gases in the gas-engine cylinder are at or below atmospheric pressure when the inlet is open.

Further, the air diffusing into the steam pipe must be collected there or returned to the engine while any gases escaping from the inlet of a gas engine are diffused through the atmosphere and are not noticed. The magnitude of the work of diffusion in the atmosphere is well shown by the fact that the atmosphere at Pittsburg contains only one or two parts in 10,000 more CO_2 than the atmosphere in the Rocky Mountains.

Further on Mr. Boone says that the only advantage of mixing air and steam is the lowering of the saturation point of the steam and thus preventing condensation in the cylinder. It does not lower the saturation point of steam to mix air with it. It is true that if the steam and the air pressure are added together, there will be a higher total pressure than that indicated by the temperature of the steam, but the steam will begin to condense as soon as its pressure rises above the pressure of saturated steam for that temperature, regardless of whether there is air present or not.

If air were pumped into the boiler, it would prevent condensation in the steam pipes, but it would do so only because the steam would be generated at a higher temperature and pressure than that at which it is used and, since the pressure would drop without any work being done, the steam would become superheated. The same effect exactly could be obtained by throttling the steam pressure down as it leaves the boiler, but this would be an expensive way of superheating. A common example of this effect is the action of the throttling calorimeter.

The promoters of the Christie engine do not appear to prove that the air-steam is exhausted into the atmosphere at a pressure below the atmospheric pressure. They do prove that the steam is exhausted into the atmosphere at a pressure below atmospheric pressure and this is true in a technical and in every other sense.

GEORGE L. SULLIVAN.

Bozeman, Mont.

One-Man Shifts

An editorial in a recent issue cites the pathetic case of the engineer of the Pasadena electric-light plant who was slowly ground to death in the flywheel pit of an engine, just because the municipality would not stand the extra expense of a second man for the night shift.

A somewhat similar accident happened in a small municipal electric-light plant near Minster, some four years ago, only the engineer was not killed. To the best of my recollection, the plant consisted of five horizontal gas engines, varying in capacity from 35 to 75 hp., all belted to direct-current generators and running on natural gas. The assistant engineer came on duty at midnight, which was the custom, and at about 1 o'clock a small motor which was on a shelf on the wall about 10 ft. above the floor began to spark. The engineer mounted a step ladder to adjust the brushes and as he did so the stepladder slipped to the floor.

The engineer fell over against a flywheel of one of the engines, breaking an arm and a leg, cracking several ribs and receiving internal injuries which rendered him helpless. He was found in this condition by a tramp who came into the plant at 3 o'clock to seek shelter from the cold. The tramp immediately summoned help and the engineer was taken home, where he lay for six weeks before he was able to get about again.

As the gas engines in this plant were nearly automatic in operation, the plant was kept running without a hitch as the load was light and regular at that time of the night. If it had not been for the timely entrance of the hobo the engineer would have died.

Just how far the practice of one-man shifts in power plants should be carried, is hard to decide. Even if the engineer should decide it, there are still the managers and owners to convince of the necessity of a second man for the safety of the engineer and the operation of the plant.

M. W. UTZ.

Minster, Ohio.

What Caused the Rod to Wear

As to Mr. Kernick's question, in the issue of Feb. 13, the answer is self-evident. The part of the rod remaining in the cylinder is exposed to a mixture of wet steam and air; it may be due to the natural leakage from the throttle, or perhaps from the exhaust pipe. This causes the rod to rust slightly, and when the engine makes a stroke on starting up, this rust is wiped away by the packing in the stuffing-box.

When the engine is shut down the next day a fresh surface is exposed to the oxidation process and, in the course of time, it will become uniformly smaller than that portion of rod not exposed. This might be prevented by swabbing the rod with oil before shutting down.

EDWARD H. LANE.

Kansas City, Mo.

Clearing a Fouled Feed Line

Frank H. Cordner's letter in the Jan. 23 issue, under the above heading, recalls the trouble I once encountered.

The boilers were fed by a pump equipped with extra-hard rubber discharge valves. When the air compressors were shut down, from 6 to 7 a.m. and 12 to 1 p.m., thus depriving the feed-water heater of exhaust steam and allowing the water to cool the valves, would become hard and break. The pieces would be pumped into the feed lines and clog them up.

As a remedy, a thin circular plate was drilled full of small holes and inserted [illegible] flanged joint of the feed line next [illegible]e pump. A more convenient arrangement would be a flanged tee, with the branch opening capped, and the strainer located in the flanged joint of

the tee at the discharge end. With such an arrangement the strainer can be easily cleaned after removing the cap.

WILFRED E. BERTRAND.

Philadelphia, Penn.

Home Made Water Heater

In the Feb. 13 issue, John Thorn states that I must have considerable trouble with my home-made water heater, as described in POWER of Dec. 26.

The heater works very satisfactorily at all times, and has been in use for some months past without giving any trouble in any way. He says that he is sure that nothing but steam will issue from the hot-water outlets; he is mistaken as we have hot water of a temperature of about 210 deg. F. at all times. The rumbling noise has never happened since the first time the heater was put into commission. The steam on the line is never below 100 lb. pressure and it is reduced to 45 lb. at the tanks. If the steam pressure was allowed to vibrate below the water pressure then trouble would no doubt happen.

H. L. RUSSELL.

Keams Cañon, Ariz.

Wooden Boxes Cut Shafting

The discussion on sand for hot boxes recalls an experience I had with some bearings in a steam brick dryer which may be helpful to others.

The air circulation was created by a series of butterfly fans driven by a 2-in. shaft running 200 r.p.m. in boxes made of white oak, with the end grain to the shaft.

Some time after the dryer had been in operation I had occasion to examine these boxes and found that the oil holes were filled with something which resembled tarred rope. It was soon ascertained that the wood had charred and was acting as an infinite number of minute cutting tools. The shafting at each box was cut almost in two, the cuttings resembling fine strands of tarred rope.

I renewed the shafting and put in iron boxes, which stopped the cutting trouble.

JOHN T. CHAMBERS.

Kennett Square, Penn.

Does Cold Air Cause Leaky Pipe Joints?

I do not quite agree with Mr. Normand in his letter in the Feb. 13 issue, although his statement that the joint may be leaky and the hot, dry atmosphere absorbs the small amount of escaping steam sounds all right. But what becomes of the hissing noise caused by the escaping steam; does the hot, dry atmosphere eliminate it also?

I have noticed in a number of plants that during the winter months, if the boiler-room doors are left open, the joints will begin leaking and hissing to some extent. After closing the doors the boiler room warms up and the joints stop leaking, though if a practice is made of letting cold air strike the joints, it means making new ones.

The cold air strikes the pipe and causes it to contract, thus shortening its length. The pull comes on the joints, and this to a great extent prevents the bolts from contracting. Contraction and expansion, often repeated, soon start a leak which would not happen if the temperature in the boiler room remained nearly constant.

L. J. OLLIVER.

New Bedford, Mass.

An Inexcusable Loss

Under the above heading, in the Feb. 13 issue, Roscoe S. Helvie gives some figures showing the loss incurred by unnecessarily increasing the clearance of steam engines by using elbows, long nipples, etc., between the cylinder and the cylinder cocks.

After the engine has taken up its load it would seem to me that the cylinder cocks, or drain valves, could be closed, and that the nipples and elbows would in a few seconds become filled with the water of condensation and stay filled, until the engine was stopped, and the cylinder cocks again opened. In this case the clearance would not be much affected.

B. COPPING.

Oliver Springs, Tenn.

Joining Leather Belting

My experience has been that wire lacing is the most satisfactory. The ideal belt is the endless belt, when there is some way to take up the stretch, but this is seldom the case except with electrical machinery.

But any old kind of wire will not give good results; it must be suitable for lacing. (The kind we use is not advertised in POWER, but it should be.) There are four sizes of wire which may be used to mark off the holes for 2-in. belts or over, start ¼ in. from the side and punch a hole every ½ in. The holes should not be much further back from the ends of the belt than its thickness, or a long joint will result which should be used only in endless belts. The punch should not exceed twice the diameter of the wire used.

A good rule for finding the length of the wire is to multiply the width of the belt by 7 for single belts, and by 9 for double belts. We have belts laced this way which are from 1 to 24 in. wide and run on pulleys with diameters of from 3 in. to 24 ft. Our main engine belt is 24 in. wide for a 24-ft. flywheel making 80 r.p.m.

Where new holes have to be made, the lacing may have to be renewed in 9 or 12 months, but the second lacing can be sunk below the face of the belt; then there will be no wear on the wire and it should last until the belt has to be taken up.

Belts over 6 in. wide should be laced in sections. For our 24-in. belt we cut the wire the same length as for four 6-in. belts; this method makes it easier to handle the wire.

S. F. RISE.

Lebanon, Penn.

The British Thermal Unit

Referring to the editorial on "The British Thermal Unit," in the issue of Feb. 27, it is to be regretted that President Bolton, of the American Society of Heating and Ventilating Engineers, did not have at hand the most recent books in which the heat unit is defined. If he had, he would have found that the old definitions in which the temperature of the water is 32 deg. or about 39 deg. are no longer used by good authorities, and that there is a general acceptance of the unit used by Marks and Davis in their "Steam Tables"; viz., the average heat per degree rise of temperature between 32 deg. and 212 deg., or $^1/_{180}$ of the heat required to raise 1 lb. of water from 32 deg. to 212 deg. The reasons for the adoption of this "mean B.t.u." are given in the introduction to Marks and Davis' "Steam Tables and Diagrams," page 6, and they appear to be conclusive.

WILLIAM KENT.

Montclair, N. J.

Indicator Cords Responsible for Diagrams

It is entirely possible, and very likely, that the peculiarities regarding the length of the diagram described by R. A. Cultra in the Feb. 27 issue were caused by the stretch of the indicator cord. This stretch was probably due to the use of guide pulleys (two of which were used) and not to the tension of the additional spring used for convenience in handling the cord.

The head-end diagram taken from an 18x42 Corliss engine was ¼ in. shorter than the other. Separate indicators operated from the same pantograph were used. Presumably, the cord leading to the head-end indicator was between 8 and 10 ft. long.

The frictional resistance caused by guide pulleys greatly increases cord stress, as may be shown by a simple experiment. Fasten a spring balance to a cord running straight from an indicator drum and draw the drum out by hand until it occupies the position assumed at the crank end of the engine stroke. In this position note the force

indicated by the spring balance. Now, pass the cord over the guide pulley attached to the indicator so as to take a half turn around it and repeat the procedure. It will be found that the force necessary to pull out the drum will be between 25 and 50 per cent. greater than in the first case. If the drum is now allowed to return to its head-end position, the force indicated will be less by this same percentage (just before the stroke is reversed) than when the cord runs straight.

Normal values of the extreme forces on the cord under the conditions cited, if no pulleys are used, are 1 lb. at the head and 2 lb. at the crank end. Then the effect of guide pulleys may be to make these ½ lb. and 3 lb. Thus there is lost motion at both ends of the drum stroke corresponding to the stretch induced by 2½ lb. instead of 1 lb.

Regular grades of indicator cord will stretch anywhere between 0.01 and 0.04 in. per foot for each pound. A 10-ft. cord stretching 0.02 in. per pound per foot (a very good quality) would have the effect noted by Mr. Cultra since its total stretch for 1½ lb. would be

$$0.02\ in. \times 10\ ft. \times 1.5 = 0.30\ in.$$

An indicator diagram shortened in this way will be very materially in error at all parts where the lines are not horizontal.

Of course, in the case cited, the shortening may have been due to something else, such as slanting cord or unequal drum diameters, but it is more likely due to the stretch of the cord.

There is a good deal of misconception about the stretch of an indicator cord. It is an elastic material and, like all such, will not stay stretched after being stressed, but will quickly resume its original length.

JULIAN C. SMALLWOOD.

Syracuse, N. Y.

In the Feb. 27 issue, R. A. Cultra asks whether the discrepancy in length of certain diagrams might not be due to the stretch of the indicator cord. No matter how old a cord may be, or how often it may have been used, it will stretch when it is subjected to tension. In proof of this, take a cord, new or old, and stretch it by suspending a pound weight; then after making two ink spots on the cord, 3 or 4 ft. apart, add about 10 lb. more weight.

By carefully tramming the distance between the spots in each case, the degree of stretch may be ascertained. The respective amounts of pull of the drum springs are readily ascertained either by weights or by spring balance, and the tensions in use can be very closely approximated and the relative stretch measured. If the indicators have paper drums and drum pulleys of the same size, then Mr. Cultra may look for the same discrepancy in the length of the diagrams, the cord which stretches the more yielding the shorter diagram. Such measurement of stretch should, of course, include the tension due to the spring which he states was employed for taking up the cord from the pantograph.

Interposition of guide pulleys has the effect of "bunching up" and making the stretch act irregularly, and it is one of the commonest causes for consecutive diagrams showing apparent variation in valve action. This may be the reason for the discrepancy in compression in the diagrams illustrated, by concentrating the effect of stretch in different parts of the respective diagrams. With diagrams taken properly in other respects, it is hardly likely that this discrepancy would exist with any good form of reducing motion, though there is no telling what might happen by employment of a pantograph motion, especially if the indicator cord was fastened, as in the case of the head-end indicator, to one end of a spring which was attached to the cord leading from the pantograph.

After very little use, the joints of a pantograph become worm and loose and are liable to produce crazy and ununiform diagrams, no matter how skillfully the reducing motion may be connected up and used. An additional source of error and uncertainty would arise from making the indicator cord fast to the cord from the pantograph or to the end of that cord, with the latter secured to a spring having one end fast to the floor, as described by Mr. Cultra. No matter how light this spring might be, it would set up some degree of wobbling motion tending to produce a shorter and imperfect diagram.

Though both indicators may take their motion from the same pin on the pantograph reducing motion, Mr. Cultra may expect to obtain shorter diagrams from the indicator connected to the head end of the cylinder, not only because it involves the use of more total length of cord, but also because of the lost motion arising from the wobble of the pantograph cord at the point where the indicator cord and pantograph cord are attached to the spring which is secured to the floor. I would suggest, however, that before attempting any refinement in analysis of the diagrams, he obtain diagrams with a better form of reducing motion than the pantograph. The best forms of reducing motions are none too good.

FRANKLIN VAN WINKLE.

Paterson, N. J.

Shooting Out Keys

I read with interest Mr. Tomlinson's article "Shooting Out Keys," in the Feb. 27 number.

Here in the soft-coal region, where the services of experienced shotfirers are obtainable, a somewhat simpler method is used. A small piece of dynamite is laid against the end of the key to be moved, and in the keyway. It should not, of course, project into the hub, in case the key does not come clear through, unless the hub is to be split. Sometimes clay is laid on the dynamite.

Inexperienced men should begin operations with an exceedingly small charge, gradually increasing it until the results desired are produced. What a piece as long as one's thumb will do is surprising to the uninitiated. Dynamite is, of course, only used as a last resort when mechanical means fail, as they sometimes do on a "hurry-up" repair job.

F. D. BUFFUM.

Ellsworth, Penn.

Automatic Pump Regulator

The automatic pump regulator described by Mr. Lehman in the Mar. 5 issue is rather unusual and, while it no doubt works, it appears to be a sort of "merry-go-round" affair.

Suppose the tank to be full of water and none is being drawn out. With the ordinary pump regulator the pump does not run as long as the tank remains in this condition. If the tank is controlled by Mr. Lehman's pump regulator, as soon as the overflow has stopped, the water drains out of the pail and the weight on the valve lever over-balances the weight of the pail and opens the valve and starts the pump. Water is pumped into the tank on the roof and as the tank is full it runs out of the overflow into the pail, causing the valve to shut and stopping the pump. As soon as the overflow is drained out the pump will start up again and the above cycle will be repeated.

As long as there is a supply of steam to the pump this operation will keep on indefinitely and in a short time enough steam would be wasted to pay for the cost of any one of the many types of automatic pump regulators on the market.

W. I. DURAND.

Brooklyn, N. Y.

Knocking in Air Compressor

In the issue of Mar. 5, page 341, C. R. McGahey says: "Mr. Richards is mistaken when he says that a machine can be run with much variation in the length of the side rods."

I have not made any such statement. In the "straight-line" compressor under discussion, with the crosshead shown in the former sketch, a swiveled crosshead with a long reach between the side rods, slight differences in the lengths of the rods, including the $\frac{1}{16}$ in. mentioned, would make no difference in the running. The crosshead sketched in the issue of Mar. 5 is a different and stiffer affair than that previously shown and is

not an appropriate illustration of the point under discussion.

It seems to me unnecessary to discuss the knockings which result in compressors or engines from slack or lost motion in rods or bearings.

FRANK RICHARDS.

New York City.

Supplementary Exhaust Valves

In the issue of Feb. 20, Mr. Bonn tried to explain the extra exhaust valves I put

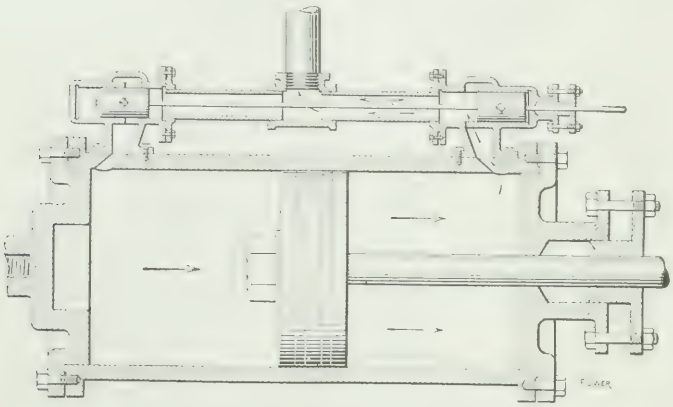


FIG. 1. DESIGN AND ARRANGEMENT OF AUXILIARY VALVES

on an 18x28-in. engine. He would have a very poorly running engine (if it would run at all) if he put them on as his drawing shows.

The pistons are far too short to cover the exhaust ports while the steam acts on the main piston; furthermore, he has the valves too high for economical operation. He states that the engine has

FIG. 2. MANNER OF CONNECTING EXTRA EXHAUST VALVES TO VALVE GEAR

been 12 years in service; the fact of the matter is it was built 35 years ago.

The engine runs at 110 r.p.m. and should be able to deliver 150 hp. with 90-lb. gage steam pressure. Whenever the load increased to 100 hp. the speed dropped to 106 r.p.m. To find the engine trouble I bought an indicator outfit for the money I received for selling an old boiler which my employer gave me. I could not detect any leaks after testing the piston and valves. The exhaust pipe was clear. I then measured the exhaust ports; they were 12 in. long and 1¼ in. wide, and they seemed rather small.

More power was wanted in the factory, so I sent some diagrams and the area of the steam ports to the engine company. It would not do anything to the engine; it blamed the piston and valves for the back pressure. I suggested some extra exhaust valves, but the company would not take the responsibility.

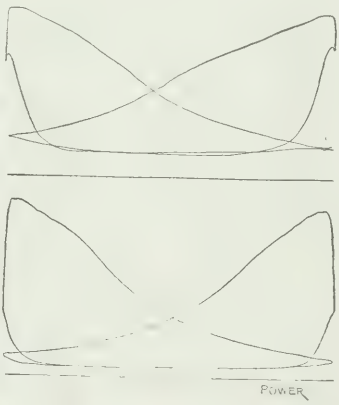


FIG. 3. DIAGRAMS TAKEN BEFORE AND AFTER VALVES WERE PUT ON

Then I went ahead on my own responsibility. I made a drawing and had some castings made by a local machine shop and put the extra valves on top of the cylinder, as shown in Figs. 1 and 2. The diameter of the valve pistons is 3 in.; the slots in the cylinder are 5x1½ in. These valves should have been larger, but I would not risk the chance of weakening the cylinder.

The diagrams in Fig. 3 indicate the conditions in the cylinder before and after the change was made. The back pressure shown by the lower set of diagrams is 4½ lb. There are over 4000 ft. of pipe on the exhaust line in the winter, during which season these diagrams were taken.

Fig. 2 shows how the valves are controlled from the regular eccentric. The engine is running now at 110 r.p.m., regardless of the load, and I have reduced the grate area 4 sq.ft. The machines throughout the factory are running uniformly and everybody, including myself, is pleased.

WENDELIN SENGE.

South Bound Brook, N. J.

See the Hump

Phil Lighte asks for an explanation of the "humps" in a pair of diagrams reproduced in the issue of Mar. 5.

It is evident that these humps are not true representations of a change in pressure inside the engine cylinder and I believe that they are due to lost motion in the indicator. The only part of the instrument influenced by the change of excess pressure from the bottom to the top of the indicator piston is the spring, which, from having been under compression, comes under tension. The pencil, levers and piston simply register the humps, the lost motion being on either or both ends of the spring. Perhaps it may not be screwed up tight.

Although the humps cannot be shown up plainly in the compression lines, on account of these lines being almost vertical where they pass the atmospheric line, the humps manifest themselves there to the same amount.

The result of this lost motion is that the part of the diagram above the atmospheric line is raised the amount which the continuation of one part of the expansion line is above the remaining part. The mean effective pressure shown will be too high.

That four of the diagrams taken showed the humps and the other not, points to the tightening up of the screw and spring without the knowledge of the operator. This may possibly have resulted from the swinging of the pencil arm back and forth toward the drum, while taking the diagrams, which sometimes drags along the cap, to which the top part of the spring is fastened. This will increase or reduce the lost motion in a loose spring, according to the direction in which the cap turns.

RULOF KLEIN.

New York City.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Watts Required for a Car to Ascend a Grade

If a trolley car weighs 8 tons, the passengers 2 tons, and the efficiency of the motors is 75 per cent., how many watts are supplied to the motors when the car is propelled up a 7 per cent. grade at a speed of 12 miles an hour?

G. O.

The total weight of the car and its load is

$$8 + 2 = 10 \text{ tons}$$

and the distance traveled per minute is

$$\frac{12 \times 5280}{60} = 1056 \text{ ft.}$$

A 7 per cent. grade means a vertical rise of 7 ft. in every hundred traveled; therefore the vertical rise in feet per minute would be

$$1056 \times 0.07 = 73.92$$

The foot-pounds of work done per minute by the motors would be

$$20{,}000 \times 73.92 = 1{,}478{,}400$$

and as 1 hp. equals 33,000 ft.-lb. per minute, the horsepower developed by the motors would be

$$\frac{1{,}478{,}400}{33{,}000} = 44.8$$

The watts output of the motors would be

$$44.8 \times 746 = 33{,}420.8$$

As the efficiency of the motors is 75 per cent. their intake would be

$$\frac{33{,}420.8}{0.75} = 44{,}561 \text{ watts}$$

Assuming the tractive force to be 25 lb. per ton, the foot-pounds of work done per minute by the motors if running on the level road would be

$$1056 \times 250 = 264{,}000$$

and the watts delivered

$$\frac{264{,}000 \times 746}{33{,}000 \times 0.75} = 7957$$

The total power required for the car to ascend the grade would be, therefore,

$$44{,}561 + 7957 = 52{,}518 \text{ watts}$$

or 52.52 kw.

Specific Gravity

How is the specific gravity of a solid determined?

C. L. A.

The specific gravity of a substance is its weight compared with an equal bulk of pure water. A solid immersed in a fluid will displace exactly its own volume, and the loss of weight of a body equals the weight of the fluid which it displaces. For example, a solid weighed in air was 60 oz. when suspended from the scale beam and when weighed in a vessel of water it was only 50 oz. Therefore, the weight of an equal bulk of water was

$$60 - 50 = 10 \text{ oz.}$$

and the solid would be $\frac{60}{10} = 6$ times heavier than water.

Changing Direction of Rotation of Engine with Shaft Governor

How can the direction of rotation of an engine with a shaft governor be changed?

W. C. C.

Change the position of the eccentric and all the governor parts. The pivoted ends of the levers should always lead and the weights follow. Engine manufacturers usually have extra bosses cast on the proper flywheel arm, and sometimes drilled to facilitate such a change when desired.

Steam per Horsepower per Hour

What is the rule to find the steam consumption per horsepower per hour?

B. E. D.

The only way to find out how much steam an engine is using per horsepower per hour is to measure both the power and the steam. The power can be measured with a prony brake or an indicator, and the steam by measuring or weighing the feed water if the boiler supplies nothing but the engine. The amount of steam can also be found by condensing and weighing it as it leaves the engine.

Starting Up a Condensing Engine

When starting up a condensing engine with a jet condenser, should the injection valve be opened before or after starting the engine?

M. V. L.

The injection valve should be opened after the engine has been warmed up, and the engine should be started immediately after the valve has been opened. When shutting down, close the throttle first, and when the speed of the engine has been materially reduced, close the injection valve.

Thickness of Cylinder Walls

What is the rule for the thickness of the cylinder walls of an engine?

F. W. K.

Multiply the initial pressure in the cylinder by the cylinder diameter, divide the result by 4000, and add 0.06 to the quotient. Example: Initial pressure = 95 lb. Cylinder diameter = 20 in.

$$\frac{95 \times 20}{4000} + 0.6 = 1.075 \text{ in.}$$

for the wall thickness.

Three-phase Motor on a Two-phase Circuit

Will a three-phase motor run on a two-phase circuit?

D. E. W.

Yes; but not satisfactorily, because the rotating magnetic field would be unsymmetrical and one of the phases would be nonoperative. The motor would have less than two-thirds of the capacity that it would have on a three-phase circuit. If delta-wound, one of the legs of the winding would have to be disconnected from the others.

Liquid Air

Can liquid air be frozen?

J. S.

No. Prof. Dewar found when the temperature of liquid air was reduced to —346 deg. F. it became apparently solid or frozen. But when the solid mass was placed in a strong magnetic field, the oxygen was drawn out toward the poles of the magnet in a liquid form, showing that nitrogen may be frozen at —346 deg. F. The temperature at which liquid oxygen freezes has not yet been determined.

Compressing Oxygen

Can oxygen be compressed in an ordinary air compressor to a pressure of 1500 lb.?

P. G.

An ordinary air compressor will not do because the oxygen attacks the cast iron, and noncorrosive metal must be used. Also oxygen may form a dangerous explosive mixture with lubricants. Special machines are built which will successfully compress oxygen to 4000 lb. per square inch.

Uniform Boiler Specifications

Recommendations by the committee on uniform boiler specifications of the American Boiler Manufacturers' Association, for changes in the Massachusetts boiler laws.

Since its first convention in 1889, the American Boiler Manufacturers' Association has striven for uniform boiler specifications. The first move was directed chiefly toward the material used, and it was largely through the efforts of this association that steel was substituted for iron in boiler construction at that time.

Later the association directed its attention toward construction and workmanship. A committee met at Atlantic City in the summer of 1898 and formulated rules covering in a practical and general manner all the important details of material and workmanship in boiler construction. These rules were officially adopted at the annual convention of the association at St. Louis in the fall of that year.

Subsequently, the association tried to have the use of these rules made imperative in a number of states, but in every case legislative action proved futile, and it was then decided that more could be gained by instituting an educational campaign, with the hope that legislative action would follow.

Two of the states, Massachusetts and Ohio, have already adopted laws along the lines laid down, and at the 1909 session of the American Boiler Manufacturers' Association a general indorsement of the Massachusetts rules was passed, subject to such improvements and amendments as the association deemed necessary.

At the convention in Boston last year a request was made of those members living in Massachusetts to make suggestions for such modifications as their experience would seem to warrant. A committee was appointed and after careful consideration it made a number of recommendations for changes in the present Massachusetts boiler rules.

It was recommended that part 2, section 1, be changed so as to make the allowable pressure, 15 lb. instead of 25 lb. per square inch, on a boiler constructed wholly of cast iron, such boilers to be used only for heating purposes; that heating boilers built entirely of steel have a pressure not exceeding 25 lb. per square inch.

Paragraph 7, section 1, of the Massachusetts rules states that the lowest factors of safety used for boilers the shells or drums of which are exposed to the products of combustion and the longitudinal joints of which are of lap-riveted construction, shall be, for boilers not over 10 years old, 5; over 10 and not over 15 years old, 5.5; over 15 and not over 20 years old, 5.75; 6 for boilers over 20 years old; and 5 for boilers the longitudinal joints of which are of lap-riveted construction and the shells or drums of which are not exposed to the products of combustion.

The committee objects to this and recommends that it be changed, holding that the factor of safety should be based upon the actual physical condition of the boiler at the time of inspection rather than upon its age.

It also disagrees with the general prohibition of cast-iron seats for safety valves, as stated in section 8, holding that the universal satisfactory experience on the navigable waters of the Mississippi valley, with lever type safety valves having cast-iron seats precludes this discrimination.

Paragraph 9 now states that safety valves hereafter installed on boilers shall not exceed 5 in. in diameter and shall be of the direct spring-loaded type with the seat and bearing surface of the disk inclined at an angle of about 45 deg. to the center line of the spindle; and designed with a substantial lifting device so that the disk can be lifted from its seat with the spindle, not less than one-eighth the diameter of the valve, when the pressure on the boiler is 75 per cent. of that at which the safety valve is set to blow.

The committee disagreed with this on the ground that the experience of reputable manufacturers of standard pop safety valves shows the flat seat to be equally safe and effective.

Regarding paragraph 11, it claims that the maximum diameter of the fusible metal of safety plugs should not exceed ¾ in., whereas the law now states that the least diameter of fusible metal shall not be less than ½ in., except for working pressures over 175 lb., or when it is necessary to place a fusible plug in a tube, in which case the least diameter of fusible metal shall not be less than ⅜ in.

Section 6, paragraphs 1 to 3, of the present Massachusetts rules, relating to the hydrostatic pressure test, states that when a boiler is tested, the maximum pressure applied shall not exceed 1½ times the maximum allowable working pressure, except that twice the maximum allowable working pressure may be applied on boilers permitted to carry not over 25 lb. pressure per square inch of on pipe boilers. Furthermore, when making annual inspections on boilers constructed wholly of cast iron or on pipe boilers a hydrostatic pressure test of not less than 1½ times and not more than twice the maximum allowable working pressure shall be applied; also, the boiler inspector, after applying the hydrostatic pressure test, shall thoroughly examine every accessible part of the boiler, both internal and external.

The committee recommends that this be changed to conform to the American boiler specifications, section 30, which prescribes that the hydrostatic test be made on completed boilers built strictly according to these specifications, is never to exceed the working pressure by more than one-third of itself, and this excess shall be limited to 100 lb. per square inch; the water used for testing to have a temperature of at least 125 deg. F.

In place of paragraphs 1 to 3, section 1, part 3, of the Massachusetts rules, covering the chemical and physical properties of metal to be used, it is recommended that paragraphs 1 to 3 of the Uniform American Boiler Specifications be substituted; these are as follows:

1. CAST IRON—Should be of soft, gray texture and high degree of ductility. To be used only for hand-hole plates, crabs, yokes, etc., and manheads. It is a dangerous metal to be used in mud drums, legs, necks, headers, manhole rings or any part of a boiler subject to tensile strains; its use is prohibited for such parts.

2. STEEL—Homogeneous steel made by the openhearth or crucible processes, and having the following qualities, is to be used in all boilers:

	Tensile strength, pounds
Flange or boiler steel	55,000 to 65,000

"When it is stipulated that the plates are to be flanged, the physical properties shall be the same as required for firebox steel."

	Tensile strength pounds
Firebox steel	52,000 to 62,000
Extra soft steel	45,000 to 55,000

	Elongation in 8 in., per cent.
Flange or boiler steel	25
Firebox steel	26
Extra soft steel	28

Elastic limit to be not less than one-half of the ultimate tensile strength.

	Chemical requirements	
	Sulphur, per cent.	Phosphorus, per cent.
Flange or boiler steel	0.03	0.04
Firebox steel	0.03	0.04
Extra soft steel	0.03	0.04

For all plates the elastic limit to be at least one-half the ultimate strength; percentage of manganese and carbon left to the judgment of the steel maker.

Test section to be 8 in. long, planed or milled edges; its cross-sectional area not less than one-half of one square inch, nor width less than the thickness of the plate.

BENDING TEST—Steel up to ½ in. thickness must stand bending double and being hammered down on itself; above that thickness it must bend round a mandrel of diameter of 1½ times the thickness of plate down to 180 deg. All without showing signs of distress.

Bending test piece to be in length not less than 16 times thickness of plate, and rough, shear edges milled or filed off. Such pieces to be cut both lengthwise and crosswise of the plate.

All tests to be made at the steel mill. Three pulling tests and three bending tests to be made from each heat. If one fails the manufacturer may furnish and test a fourth piece, but if two fail the entire heat to be rejected.

Certified copies of tests to be furnished each member of the American Boiler Manufacturers' Association from heats from which his plates are made.

3. RIVETS to be of good charcoal iron, or of a soft, mild steel, having the same physical and chemical properties as the firebox plates, and must test hot and cold by driving down on an anvil with the head in a die; by nicking and bending, by bending back on themselves cold, without developing cracks or flaws.

For paragraph 16 of the same section of the Massachusetts rules it is recommended that the table of allowances for overweight on plates be omitted and the following rule substituted: Plates will be considered up to gage if measuring not over 0.01 in. less than the specified gage The committee holds that the paragraphs 1 to 3 of section 2, part 3, relating to the material used in the shell plates, heads and rivets, should be annulled and that the qualities ascertained by actual tests should be conclusive as defining the material to be employed instead of such indefinite designations as "flange," "firebox," or "extra soft" steel, which are the terms at present specified.

Paragraph 7 of the same section now states that mud drums of water-tube boilers shall be of wrought or cast steel when the working pressure exceeds 160 lb. per square inch. It is recommended that this be amended by prohibiting the use of cast iron for mud drums.

The committee recommends that section 3, paragraph 2, of the present rules providing that the stamp (Massachusetts standard) shall be affixed by the inspector, etc., should not be construed to compel the manufacturer to stop or retard work in process or prior to completion on account of the temporary absence of the inspector.

It is further held that paragraph 6, section 4, which limits boilers of lap-riveted construction to 100 lb. per square inch and to a diameter not exceeding 36 in., is not warranted by the experience of reputable boiler manufacturers. Lap-riveted boilers 48 in. in diameter have been and are in successful use on the Mississippi River.

Also, it is suggested that paragraph 10, section 4, which provides that the thickness of plates in a shell or drum shall be of the same gage, should be modified so that a manufacturer while using plates of sufficient gage under these rules may employ them with other plates of a somewhat thicker gage which he happens to have in stock.

In paragraph 16, which deals with bumped heads, it was found that there has been considerable misunderstanding in regard to which is a convex head and which is a concave head. It is suggested that these heads be designated as "externally convex" and "externally concave." Furthermore, it is suggested that 0.8 be substituted for 0.6 as the constant in the formula for the minimum thickness of an externally concave head.

$$t = \frac{R \times F.S. \times P}{0.6\ (T.S.)}$$

in which R is one-half the radius to which the head is bumped; $F.S.$ is the factor of safety; P the working pressure; $T.S.$ the tensile strength as stamped by the manufacturer, and t is the thickness of the head in inches.

To avoid misunderstanding it is recommended that paragraphs 17 and 18 be combined as one so that it may be thoroughly understood that the convex or concave head, which has a manhole, shall have an increased thickness of ⅛ in. and a turned-in flange of a depth not less than three times the thickness of the head.

As to paragraph 19 it is held that the word "flat" should be omitted so that the minimum thickness of plates in all stayed surfaces shall be $\frac{5}{16}$ in.

The committee would so amend paragraph 21 that an increased pitch of not over 1½ in. be allowed in the staybolt adjacent to the furnace door or handhole opening, but in one direction only.

In paragraph 23, relating to staybolts, it is recommended that for small heating boilers limited to 25 lb. and under, no staybolts be required. Also, in paragraph 25, to avoid misunderstanding, it is suggested that the language be so amended that the pitch of staybolts shall be measured on the inside of the furnace.

For paragraph 32, it is contended that the stays specified on each side of the manhole in horizontal return-tubular boilers should not be required to pass through the front head because of the difficulty in keeping these joints tight; and that other equally strong means of staying may be adopted.

The committee believed that paragraphs 40 and 41 relating to cast-iron nozzles and flanges should be placed in harmony with the present manufacturers' standard.

Paragraph 43 states that rivet holes, except for attaching stays or angle bars to heads, shall be drilled full size with the plates, butt straps and heads bolted in position; or they may be punched not to exceed ¼ in. less than full size for plates over $\frac{5}{16}$ in. in thickness, and ⅛ in. less than full size for plates not exceeding $\frac{5}{16}$ in. in thickness, and then drilled or reamed to full size with the plates and heads bolted in position. The committee believes this should be amended so as not to apply to holes in the fittings.

It is recommended that paragraph 45 be eliminated, because it cannot be complied with in the case of rivets driven by air tools or by hand, which must always be employed where hydraulic riveters cannot reach them; and a rule should not discriminate against smaller boiler shops unable to use hydraulic riveters.

It is suggested that paragraph 48 be amended by omitting everything after the word "chamfered," so that it shall read: "The edges of tube holes shall be chamfered."

In paragraph 49, the word "carefully" is believed to be better than "substantially"; the rule will then read: "A fire-tube boiler shall have the ends of the tubes carefully beaded."

It is held that paragraph 53 should be amended to allow the use of pressed-steel and wrought-iron nozzles in addition to those specified.

The word "oval" is suggested instead of "elliptical" in designating the shape of the manhole opening, paragraph 54.

Paragraph 59, to be amended to permit the use of cast-iron manhole plates which are universally used in the boilers in the Middle West.

An amendment is suggested for paragraphs 60 and 61 so as to make it optional whether a manhole or a handhole shall be used in the front head of horizontal tubular boilers.

The committee recommends that paragraph 62 be eliminated, because it is a very difficult and precarious thing to keep a handhole in good order in the rear head of a horizontal tubular boiler below the tubes.

The requirement of a handhole near the throat sheet of a horizontal tubular boiler should be eliminated by striking out the words "also where possible one near the throat sheet," paragraph 63.

In paragraph 65, that ¾-in. be substituted for the 1-in. pipe size.

Paragraphs 67, 68 and 69, which definitely prescribe the hanging or support of large tubular boilers, should be eliminated and manufacturers permitted to follow their present practice which has been proved safe.

It is recommended that paragraph 70 be struck out, and paragraph 31 of the Uniform American Boiler Specifications be substituted.

Section 5, paragraph 3, should be changed from 2 in. to 3 in.

Paragraph 5 is sometimes misunderstood, and should be rewritten to make it clear that two valves are required to be placed on any individual steam pipe leading from a boiler to a steam main or to another boiler, in the interest of the safety of any man entering the boiler

while the other boiler or boilers are in service.

The committee believes that 100 lb. should be substituted for 135 lb. in paragraph 18.

Regarding paragraph 23, it is suggested that the words "except such portion of the piping as is exposed to the gases of combustion" be added.

The committee believes that paragraph 31, relating to the support of boilers, should be placed under section 1, part 2, referring to cast-iron boilers.

That in paragraph 3, of section 6, the sentences (a) and (b) be cut out, as they discriminate against lap-riveted joints which are in satisfactory use in thousands of boilers in the Middle West. Also that sentences (d) and (e) be eliminated, and that the factor of safety be based on actual conditions of the boilers instead of their age.

It is further recommended that the last sentence covering the hydrostatic-pressure test should be struck out and that paragraph 30 of the Uniform American Boiler Specifications be substituted.

of the boiler plant. Details of the system are shown in Fig. 1.

The plant consists of an engine-driven blower outfit, the speed of which is controlled by the variation of steam pressure in the boilers, and the fan delivers air at any desired pressure to the ashpit of the furnace. A means is also adopted for adjusting the relative air supply and outflow of waste gases so as to obtain a determined rate of combustion while maintaining practically atmospheric pressure in the combustion chamber. This arrangement also prevents the influx of cold air at the furnace doors during the firing period, or through cracks in the setting.

The Acme system of controlled combustion accomplishes an economy in the operation of the steam plant by supplying the greater portion of the entire load demand of the plant from a number of the boilers. Each boiler of the constant group is operated under such fixed conditions of combustion as may be best suited to its particular requirement. The remaining or fluctuating portion of the load demand is supplied from a further number of boilers which are variably operated for this purpose. In this manner a major portion of the total vaporization requirement of the plant is supplied from an appropriate number of boiler units, operated under conditions approaching as closely as possible to maximum efficiency. The losses, therefore, attendant upon the regulation of combustion to meet fluctuations in the load are confined to a comparatively smaller number of variably operated units and are correspondingly reduced.

The regulation of the boilers which serve as the constant supply units is obtained by introducing a constant de-

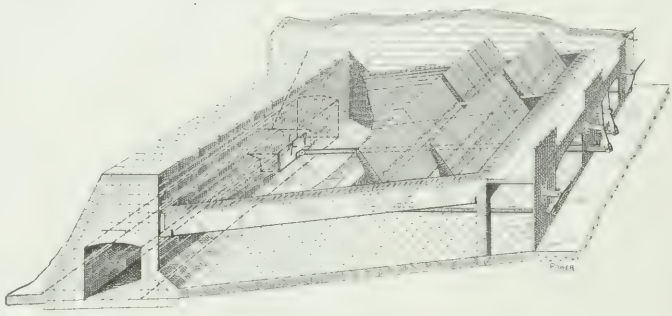


FIG. 2. AIR DUCT IN BRIDGEWALL

Acme System of Controlled Combustion

The Acme system of controlled combustion is designed to maintain a highly heated zone for the union of the liberated gases with a proper amount of oxygen, to retain the gases of combustion in contact with the heating surface of the boiler the greatest possible time, and to confine the variability of load service to a part

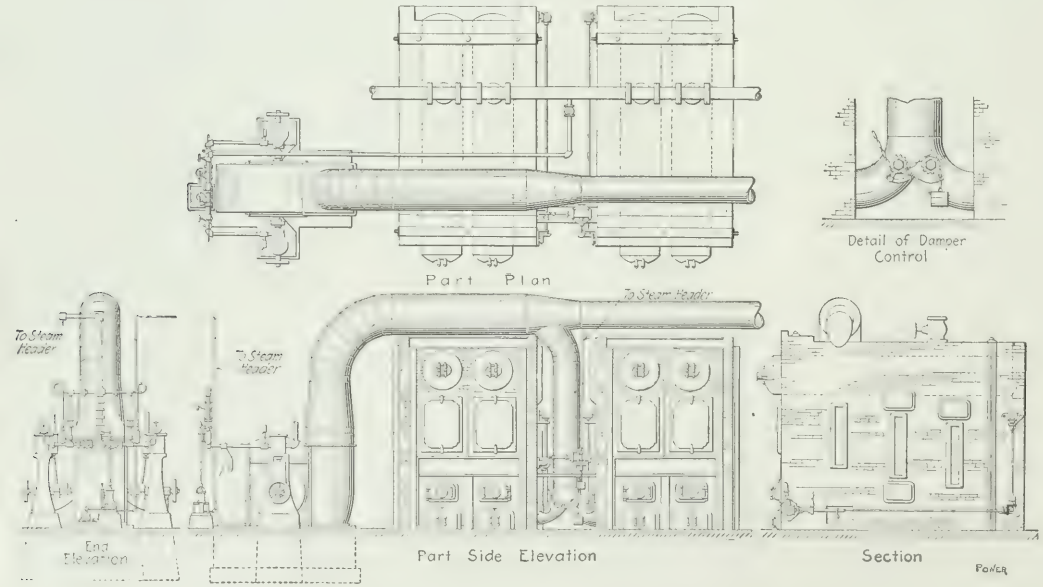


FIG. 1. ACME SYSTEM OF CONTROLLING COMBUSTION

livery of forced air into the ashpit and adjusting the stack dampers so that the approximate atmospheric furnace pressure is normally maintained.

The regulation of the variable supply units is accomplished by varying the amount of forced draft admitted to their ashpits, the stack dampers of such variable units remaining in a fixed position of adjustment which is suited to their normal or average requirement. The air duct to the ashpit is shown in Fig. 2. In the event of a change in load exceeding the limits of range served by the variable units, a general regulation of the constant supply units to meet the emergency is provided, the general regulation being effected by varying the force of the draft by retarding or accelerating the speed of the blower.

The several boilers are supplied with gearing interconnecting their respective stack and ashpit dampers so that by the operation of a single lever, both dampers may be simultaneously operated. The interconnecting gearing is supplied with an adjustable connection between the dampers whereby the relative positions of the two may be shifted as desired, and their simultaneous operation effected accordingly; so that with a normal or predetermined delivery of forced air, the operation of each unit will approach as closely as possible its maximum efficiency, which condition may be determined by actual test. The rate of combustion in such units will be practically constant, and variations in such operation when produced by the manipulation of the damper operating handle will maintain the same furnace pressure.

The range of the control of the variable units is fixed so as to include all such normal fluctuations of the load as occur during usual or ordinary conditions. A range of 5 lb., with an adequate number of variable units, is ordinarily sufficient to accommodate usual running fluctuations, but such range may be adjusted according to the judgment of the operator. The valve controlling the general regulation is set to respond only to changes in steam pressure exceeding the range served by the variable units, and when thus called into operation regulates the supply of forced draft to the ashpit.

The determination of the relative numbers of constant and variable-supply units for any given steam plant will depend upon the ordinary conditions of running. The constant-supply units will preferably be sufficient in number to carry the maximum constant portion of the load, while the variable units will be sufficient to perform the balance within reasonable limits of control. On occasions, when the capacity of the plant is desired to be materially or permanently changed or the range of normal fluctuations is increased or diminished, it will be necessary to alter the relative numbers of constant and variable units.

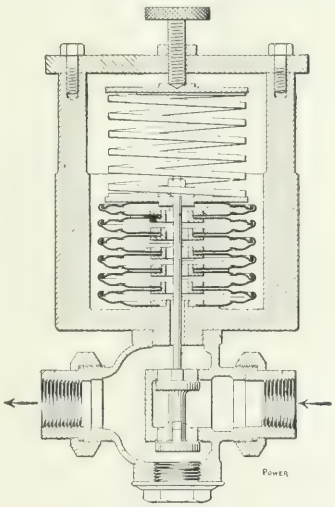
A steam-controlling valve is placed at one end of the battery and operates a shaft running to the rear of the boilers, having an adjustable connection to each of the dampers in the uptake. This valve is set to close at about 5 lb. above the normal steam pressure and is so adjusted, that a desired pressure in the combustion chamber may be readily obtained.

A second valve is placed on the other end of the battery with a shaft traversing the first one and means of connection with any of the individual dampers. This valve is set at normal steam pressure and regulates the draft on the control boiler or boilers. A simple attachment is arranged so that each damper may be closed by hand during the process of cleaning, or when putting a boiler out of commission.

This system is manufactured by the Acme Furnace Equipment Co., 39 Cortlandt St., New York City.

Ziermore Pressure Regulator

The improved Ziermore pressure regulator is illustrated herewith. All parts are made of bronze with the exception of the diaphragms which are of silver and german silver. The connecting fittings are made male and female and form a part of the diaphragm. Due to this construction it is possible to build as long a battery of multiple diaphragms as is desired to suit the throw of the valve, and also to add to or take from a diaphragm from the battery.



ZIERMORE PRESSURE REGULATOR

The lower end of the battery of diaphragms is anchored to the threaded lug of the yoke, but the upper end is free to move with the pressure on the inside of the diaphragms. To the upper end of the diaphragms is attached a bronze plate to serve as a spring support, a shoulder for the diaphragm and an anchorage for the valve rod.

The valve rod passes through the battery without friction. The upper end of the rod is anchored to the movable end and the lower end of the rod to the valve disk, thus causing it to move toward or away from its seats as the battery inflates or deflates with any change of pressure within them.

The spring tension is set against the top of the battery of diaphragms by means of the adjusting screw and the reduced pressure is thus produced and controlled.

The fluid passes through the regulator as is indicated by the arrow. The low pressure only has access to the battery of diaphragms and enters them from the low-pressure side of the regulator, through the same port which the valve rod enters.

Any change of the low pressure will cause the battery diaphragms to move, and the valve disk must move exactly the same distance.

The regulator may be placed in service in any position without interfering with its sensitive action. It is suitable for controlling steam, gas, air, water, oil and many kinds of acids. Wire-drawing is almost eliminated, and chattering is entirely unknown, it is claimed. This regulator is manufactured by the Ziermore Regulator Co., Johnsonburg, Penn.

Tubes Blow Out

Two tubes of a boiler in the Fox Co. paper mill at Cincinnati, Ohio, blew out on Mar. 3 and fatally scalded two men. It is alleged by State Inspector Huddleston in his testimony before the coroner that the boilers in the mill were not properly cared for and that proper safety precautions were not provided for the employees' safety. The boiler was said to be carrying 75 lb. pressure, about one-half the regular working pressure. A tube blew out of the same boiler on Feb. 29 and caused some damage.

The Uptodateness of Siam

John Barrett, director of the Bureau of American Republics, was once minister to Bangkok, Siam, where he had a chance to observe the Siamese method of doing business.

Shortly after the electric-light plant was installed, complaints were sometimes received from dissatisfied consumers, and the manager sent out the following on a post card:

Sir—For the case that your electric light should fail, we beg to send you with this a return post card, which please send us at once when you find your light out. The company will then be most happy to send you another post card. Yours truly, Manager Siam Electricity, Limited.

As an evidence of Oriental belief in Occidental methods of public utility, the foregoing letter is a fair sample. But, taken literally, its offer to forward a second card to the subscriber leaves one in the dark as to the quality of the light service provided by the Siam Limited.

Saves Money on Lights

It is estimated by Henry Berg, chief engineer of the Orange, N. J., municipal lighting plant, that the city has saved $10,000 in the first year of the plant's operation. It would have paid the Public Service Electric Co. at the rate of $85 a lamp, whereas it cost $60 a lamp under municipal operation.

The net cost of operation was $17,997.12. The city has 369 arc lamps and 156 tungsten lamps, an equivalent of 408 arc lamps. Thus the cost of operation and maintenance, distributed among that number of lamps would be $44.11. Interest, sinking fund, and depreciation accounts would bring the charge per lamp up to $60.

Oil Mill Superintendents' Convention

On June 12 to 14, the National Oil Mill Superintendents' Association will hold its annual convention at Memphis, Tenn. There will be a large exhibit of trade supplies, and cotton-oil and other mill machinery.

Low railroad and hotel rates will be made for the delegates and friends and intending exhibitors can obtain full information by writing to F. M. Smith, of the Oriental Oil Co., Dallas, Tex.

The Oil Mill Machinery Manufacturers and the Supplymen's associations will meet in Memphis at the same time.

NEW PUBLICATIONS

THERMODYNAMICS OF THE STEAM TURBINE. By C. H. Peabody. Published by John Wiley & Sons, New York. Cloth; 282 pages, 9x5¾ in. Price, $3, net.

The author's preface states that this is an attempt at a systematic treatment of the thermodynamics of the steam turbine for students in technical schools. The author's ability is sufficiently well known to make it easy to comprehend the degree of success with which the "attempt" has met.

Constructive details are considered so far as they are necessary for a proper understanding of the thermodynamic computations or as they are related to such computations. The methods in general are those accepted by steam-turbine designers, but certain methods have been devised by the author either to make them more complete or to provide more rapid and precise determinations of conditions and proportions.

A 13-page introductory chapter deals briefly with definitions, standards and units and is included for the convenience of reference and to avoid ambiguity.

Successive chapters deal with steam nozzles; jets and vanes; simple impulse turbines; pressure compounding; velocity compounding; pressure and velocity compounding; reaction turbines; accessories; effect of conditions, and marine steam turbines.

GAS ENGINES. By W. J. Marshall and H. Riall Sankey. Published by D. Van Nostrand Co., New York. Cloth; 280 pages, 5½x8 in.; 127 illustrations. Price, $2.

The avowed purpose of this work is to inform those who, "being either purchasers or users of gas engines, wish to know the principles underlying their design and construction, the methods of diagnosing defects when they occur, and the steps to be taken to remedy such defects." This purpose is well executed in general, although some errors and arbitrary statements have crept in which are more unfortunate, in view of the chosen audience, than they would be in a college textbook or a reference book. On page 2 it is stated that the density of water is maximum between 62 and 63 deg. F. On page 3 and elsewhere, absolute zero is put at 461 deg. F. and 273 deg. C., which values are inconsistent with each other. On page 4, Boyle's law is incorrectly stated, the word "inversely" having been omitted after the word "varies" in the fourth line. On page 19 the release temperature is put at 1400 deg. F., which is rather excessive. On page 20 an engine showing 30 per cent. indicated heat efficiency is classed as a "bad engine" and a "good engine" is accredited with an efficiency of 40 per cent. We should be glad to see an internal-combustion engine, outside the Diesel class, showing in everyday service even the "bad" efficiency cited. On page 24 the average low heat value of pressure (bituminous) producer gas is put at 155 B.t.u. per cubic foot, that of suction producer gas (anthracite) at 146 and that of suction producer coke gas at 135 B.t.u. On page 81, the primary wipercam levers are drawn upside down, as regards the common practice. On page 95, the deflector is of about twice the normal proportions and located in the center of the piston face, which is never true in practice.

Chapters II to VI of the book are commendable, but the first chapter and the last seven, dealing successively with elementary principles, cooling, ignition, engine operation, installation, testing, governing and gas production, measure up to the most exacting requirements, always keeping in mind the prefatory statement as to the selected scope. The various subjects are explained in simple, direct phraseology, devoid of unnecessary and bombastic word exercise; the exposition of principles is sound and thoroughly intelligible; the selection of examples from practice is judicious, and there is a conspicuous absence of that abomination, padding from builders' catalogs, which characterizes the work of so many "authors" who undertake to present engineering practice on paper. The book has a field of its own, lying between that of the very elementary type written for engine runners and that of the strictly scientific college textbook, and we heartily commend it to that field.

HANDBOOK ON THE GAS ENGINE. By Herman Haider. Translated from the German and edited by W. M. Huskisson. Published by McGraw-Hill Book Co., New York. Cloth; 330 pp., 6½x9 in.; numerous illustrations and tables. Price, $5.

This is the first comprehensive reference book relating to gas engines that has appeared in English. (The reviewer does not overlook Diederich's translation of Güldner's monumental work, but regards that as very much more than a reference book.) It is well arranged and the treatment is for the most part commendable. The definition of the word "cycle" on the first page is childishly wrong, but as the book is intended for the use of trained engineers that will do no harm. On page 2, however, is a statement which the translator should have edited heroically: "Single-acting two-[stroke-]cycle engines are seldom used and will not be considered in this book."

Chapter I is also weak in that it contains elementary comparisons with steam-engine operation which are inappropriate in a book of this class. This occurs also in other parts of the book, and there are many instances of dogmatism and narrow consideration throughout it. One of the most conspicuous of the latter kind is the presentation on page 19 of the ratio of actual to maximum possible explosions per minute, represented by the symbol ϵ. This applies only to hit-and-miss engines and should not be put forward as a general fundamental.

An instance of dogmatism is the statement on page 125 that trunk pistons without water cooling are almost invariably adopted for engines up to 120 hp. The inference, of course, is that all engines of 125 hp. must have water-cooled pistons. There are many engines in this country developing much more than that power with uncooled trunk pistons.

Exhaustive discussions of the design of flywheels, crankshafts and pistons are given in Chapter VII, but the reviewer is unable to find any data that would be of service in working out the simplest flyball governor, to say nothing of the Hartung and Jahns types and the still more complex flywheel type.

Chapters V and VI present excellent discussions, though somewhat verbose and rather empirical in spots, of turning moments and of the forces acting on the

main bearings and the reciprocating parts. The tone is much like that of a pompous and prolix college professor delivering a lecture. This verbosity characterizes almost the entire book and mars an otherwise praiseworthy effort, besides wasting much paper and ink. Flights of scientific oratory are out of place in an engineer's reference book.

Nevertheless, this book contains a vast amount of useful data not to be found in any other English publication (always excepting Güldner), and the author may easily be forgiven his fondness for circumlocution.

MACHINE DRAWING AND SKETCHING FOR BEGINNERS. By J. H. Robson. Published by D. Van Nostrand Co., New York. Size, 5x8 in.; 191 pp.; numerous illustrations and tables. Price, $2, net.

This book is intended for beginners and engineers desirous of taking up mechanical drawing without the aid of an instructor.

The book contains a chapter briefly describing the materials used in machine construction, another on work-shop practice and appliances, and still another is devoted to questions and answers taken mostly from examination papers.

The author has endeavored to assist the student in acquiring a knowledge of machine details by providing illustrations of various objects, many of them being fully dimensioned.

The book is particularly valuable to the engineer or student, with a practical knowledge of mechanics, who is desirous of taking up the study of machine construction.

MECHANICAL WORLD YEAR BOOK FOR 1912. Published by Emmott & Co., Manchester, Eng. Boards; 285 text pages, 4x6 in.; 100 illustrations; many tables. Price, 6d.

The twenty-fifth edition of this little annual contains new sections on verniers and micrometers, gaging cylindrical bores, roller bearings, helical springs and milling-machine work. There are also several new tables and the steam-turbine section has been expanded. The sections on gas engines, oil engines and gas producers are so limited as to be of little or no value for reference purposes. There is not even a table of engine constants, and some of the statements are out of date.

What Scale Does to Boilers

The interesting and comprehensive compilation of data on the care and treatment of boilers, published by the Harrison Safety Boiler Works, Seventeenth and Clearfield Sts., Philadelphia, Penn., now appears in the fourth edition, with uptodate and amplified statistics and considerable new engineering matter, especially in regard to recent theories in connection with the corrosion of iron by boiler-feed water.

A new chart, credited to Dr. Reutlinger, of Cologne, shows that boiler plates covered with scale may rise to temperatures two or three times as great as will clean plates transmitting heat at the same rate.

The chapter on corrosion, particularly that section relating to the rôle of air in corrosion, in which the latest results of Profs. Woodbridge and Walker, of the Massachusetts Institute of Technology; Burgess, of the University of Wisconsin, and Heyn and Bauer, of Germany, are quoted, should make interesting reading for anyone having trouble of this kind. The most valuable result brought out by these investigations is the fact that corrosion may be wholly or almost entirely prevented by heating the water by spraying through an open steam bath, thereby driving off the air and other gases. Copies of this 40-page booklet will be sent free to those interested.

Steam Tables for Condenser Work

The ordinary steam tables leave much to be desired for condenser work. The Wheeler Condenser & Engineering Co., Carteret, N. J., has issued, presumably for gratuitous distribution, a little handbook of more extended steam tables for pressures below that of the atmosphere; also including a discussion of the use of the mercury column, and constants for the correction of its indications. The tables were especially calculated for this book by Prof. Marks, and are based upon the more comprehensive tables of Marks and Davis.

There are three separate tables, the first giving the properties of steam for each tenth of an inch of vacuum from 29.8 in. to 24 in. and above this by even inches to atmospheric pressure, the vacuum being referred to a 30-in. barometer. The second table gives the properties for each degree of temperature between 32 and 212 deg., the corresponding pressures being expressed in pounds per square inch, inches of mercury (32 deg.) and inches of vacuum. The third table goes by even pounds from a gage pressure of zero to 200.

It was time for somebody to do this, and it is appropriately done by a condenser company.

Exhaust Steam Engineering

"Cochrane Heaters, their Use in Steam Power Plants for Heating and Purifying Water for Boiler Feed and Other Purposes," is the title of a 144-page publication issued by the Harrison Safety Boiler Works, of Philadelphia. The topics include the choice of a system for heating boiler-feed water; relative economics of electric and direct-driven auxiliaries vs. steam-driven auxiliaries where the exhaust from the latter is used for heating the boiler-feed water; action of spraying the water through a steam bath in driving off air and gases and thereby preventing corrosion as well as bringing about the precipitation of carbonates from the water; comparison of the thermal efficiencies of direct-acting pumps, throttling plain slide-valve engines, automatic engines, compound engines and steam turbines; effect upon fuel economy of heating boiler-feed water; steaming capacity of boilers; apparatus for utilizing exhaust steam, including feed-water heaters, oil separators, traps, tanks and automatic cold-water regulators; influence of scale upon boiler-repair bills; heating of feed water in condensing plants; utilization of exhaust steam for heating and drying work, and for the operation of low-pressure turbines; operation of open feed-water heaters in multiple; pumping of hot water; limitations of injectors; a comparison of the efficiencies and other characteristics of open feed-water heaters; analysis of the design of the several parts of an open feed-water heater; analysis of the fundamental facts of water softening as it affects central stations, manufacturing plants, etc.; the metering of boiler-feed water. Besides the catalog naturally describes the several appliances manufactured by the company for use in connection with the above mentioned branches of engineering.

Copies of this publication will be sent free to owners, engineers and operators of steam plants and others having direct interest in the subjects treated.

"Mechanical Stresses in Transmission Lines," by A. Guell, has just been issued as Bulletin No. 54 of the engineering experiment station of the University of Illinois. Of the stresses to which lines of wire for the transmission of electric current are subjected, this bulletin discusses the following: (1) dead weight; (2) wind pressure; (3) change of temperature. Approximate and exact formulas are derived for use in the calculation of such stresses. An example given shows that for very long spans and great sags the parabola method of calculation, commonly used by engineers, is inadequate. Evidence is presented to show the superior advantage of the catenary method, and also that this method is sufficiently simple and accurate to serve the purpose of practice. Copies of this bulletin may be obtained gratis upon application to W. F. M. Goss, director of the engineering experiment station, University of Illinois, Urbana, Ill.

PERSONAL

A. R. Maujer, heretofore an associate editor of POWER, attached to the main office in New York City, has been appointed Western editor, with headquarters at the Chicago office.

Moments with the Ad. Editor

Here's an interesting letter from a POWER subscriber in Brownsville, Texas—interesting because it points a moral both to advertiser and reader of advertising.

It shows the advertiser that the reader nowadays wants not only to be assured that a device is good, but also "why it will pay him to use it."

It shows the reader that reading alone isn't sufficient to get the utmost value out of the selling section—

That when an advertiser has shown the way to secure greater economy the thing to do is to act—to investigate.

1. The ad. of the General Electric Co. gives me the strongest impulse to investigate their product because, in the first place, it attracts my attention by a picture which makes a distinct impression upon my mind, while the reading matter conveys to me, in a brief manner, the fact that there is an instrument which will give correctly the amount of work each boiler is doing, a vital point in every steam plant.

Further, it mentions how, by having this information, many losses may be prevented and the general efficiency of the boiler improved.

In the second place it assures me that this instrument is not complicated or costly, as I might otherwise suppose was the case with an instrument of this kind.

Lastly, it requests me to write for a bulletin, describing the instrument more fully.

2. The steam trap ad. of the Geo. M. Newhall Co. seems to me to have the biggest educational value because it gives, both by illustration and description, a clear idea of the construction of this device and calls special attention to six of its strong points, and explains why these points are strong ones.

It also has a further educative value by telling where a person can secure, free of charge, a booklet fully describing this trap and steam traps in general.

3. The ad. of the General Electric Co. appeals to me as being the best all round ad. for the following reasons—first, it has a distinct, life-like picture to attract a person's attention. Second, it sets forth a fact in the first paragraph which holds the interest of the reader and compels him to read further, for every first-class engineer is interested in the amount of work each particular boiler in his plant is doing.

Third, the ad. is printed in large clear type, is to the point, and is so arranged that the reader reads it through in a straightforward way, and has no inclination to pass it by, until he has read it all.

Fourth, it gives just enough information to interest the engineer to the extent that he wants to know more of this particular instrument, and hence is ready to accept the invitation to send for a bulletin.

4. I have answered the ad. of the General Electric Co.

Another letter which furnishes food for thought for both advertiser and reader is this one from a subscriber in Fort Morgan, Ala.:

1. The Lytton trap "ad." They mention the fact that their trap is installed in the Delray station in Detroit, under the severest of conditions, and is giving satisfaction. This simple statement is more convincing than a half dozen long drawn out reasons why their trap is superior to others. In reading descriptions of modern plants I always notice the *kind* of apparatus installed, as there always is a reason.

2. Smooth-On "ad." Each week since I have been reading POWER I notice where some engineer has been helped over a hard place by using Smooth-On. When the water-jacket on our gas engine cracked during the recent cold spell, it was perfectly natural for me to say, "Smooth-On will fix it."

3. Ambest lubricated metallic packing "ad." The picture has a distinct educational value; it shows the construction and character of the packing; it shows how easy it is to pack a rod, and the method of packing. The arguments are logical and easily understood. The offer of a free testing sample should bring the advertiser big results.

4. I answered the Lytton and Rochester "ads."

It is true that it will only pay that manufacturer to advertise whose goods will help you improve conditions in your plant, will help you secure economical results—

But remember that this selling section will help *you* best only if you take advantage of the investigation invitations which the advertisers extend to you.

POWER

Vol. 35 NEW YORK, APRIL 9, 1912 No. 15

Some interesting experiences have been published in POWER from time to time as to the use of sand in hot bearings, and there was a wide diversity of opinion as to its value when so used. Its efficacy seems to depend upon where and how it is used, and the difference of opinion is still wide and unsettled.

The little toddler while at play in the backyard sandpile soon learns that energy, grit and perseverance are needed for it to dig its way up to the top of the heap.

And so it is with the operating engineer. He must have a heap of mental "sand" before he is equipped, for instance, to assume charge of a badly run-down plant where the stockholders' only policy is apparently to squeeze every possible dollar out of the property, and to refuse to put aside anything for its repairs and maintenance.

There are certain individuals who think that it requires "sand" to burglarize a man's home in the dead of night; to take a "dare" or needlessly risk their lives; or, knowing that the boiler plates are badly pitted or are otherwise dangerously defective, will continue to operate the boiler. Running risks when there is nothing to be gained merely indicates rashness and recklessness.

The "sand" that counts is possessed by the engineer who perseveres under almost overwhelming obstacles and wins out; he has the required grit, and backs it up by hard work. He does not recognize luck, nor chance; he gets busy and sticks to the job—and this does not mean coming on duty at 9 a.m. and knocking off at 4 p.m.

Another test for "sand," from which some engineers shrink, is that of permitting central-station men to run a test of the steam apparatus. The management takes the ground that if the central-station men can show up anything about the plant that is unknown to the management, it is high time to bring it to light.

Have you, Mr. Isolated Plant Engineer, got the "sand" to put your station to the test, or is it possible that the showing would endanger your position?

If this is the case, you need "sand," not for hot bearings, but for stiffening up your backbone, for successfully coping with your engineering problems, for creating courage to tell the management just how much needless waste is going on in the plant, and how it can best be stopped.

Pumping Plant at Sloss Iron Mines

By C. A. Tupper

A 750-kw. turbine plant supplying electrical energy to an underground pumping station equipped with four-stage centrifugal induction-motor-driven pumps installed solely for the purpose of keeping mine free from water.

To provide a modern electric generating plant solely for the purpose of keeping a mine free from water is unusual; but this was done by the Sloss-Sheffield Steel & Iron Co., Birmingham, Ala., at what are known as the "Sloss" workings on Red Mountain in Jefferson County.

Heavy Intermittent Inflows of Water

Included in these workings are two slopes of about 23-deg. pitch. The lower, designated as No. 1, is 2400 ft. southwest of No. 2. Both lie directly across from Bessemer, Ala., about 1½ miles distant. In common with other slopes on Red Mountain much trouble was caused by heavy inflows of water, that usually broke in from the overlying strata through fractures in the hanging wall. These occasional floodings were originally of relatively short duration, and little difficulty was experienced during most of the year in keeping the workings dry.

In 1909-10 the condition of No. 1 mine was greatly impaired by heavy falls of top rock, which opened up numerous channels of water and forced a shutdown of the mine. Additional pumps and the necessary pipe lines were installed, but the flow of water was so steady and of such great volume that the direct-acting steam and air pumps proved inadequate. Consequently, F. W. Hausmann, mechanical engineer of the company, in conjunction with M. J. Lide, consulting engineer, prepared the plans for a complete electrically driven pumping plant.

The Power Equipment

The pumping plant comprises a power house, in which is installed a steam-turbine generator unit of 750 kw. capacity, and an underground pumping station equipped with two 10-in. four-stage centrifugal pumps, each direct-connected to a 450-hp. three-phase 60-cycle squirrel-cage induction motor. The turbine, which operates at 3600 r.p.m., is supplied through a 6-in. feeder with steam at 125-hp. gage pressure from a battery of water-tube boilers. In its various details standard practice is followed. Three-phase, 60-cycle currents are delivered by the generator at 2300 volts. Excitation for the alternator is supplied by an engine-driven dynamo of 15 kw. at starting and by a motor-driven set of the same size while running.

The turbine is operated condensing, and the arrangements for this are somewhat unusual. All of the water pumped from the mine is discharged into a large circular concrete reservoir, with suitable gates for excess flow, situated on the side of the mountain above the power house. From this reservoir injection water at 60° F. is drawn to a 36-in. Tomlinson barometric condenser, which maintains a vacuum of approximately 28 in. referred to a 30-in. barometer. The piping and other arrangements at the power house, with provision for atmospheric exhaust when desirable, are shown in the sectional view of the station, Fig. 2.

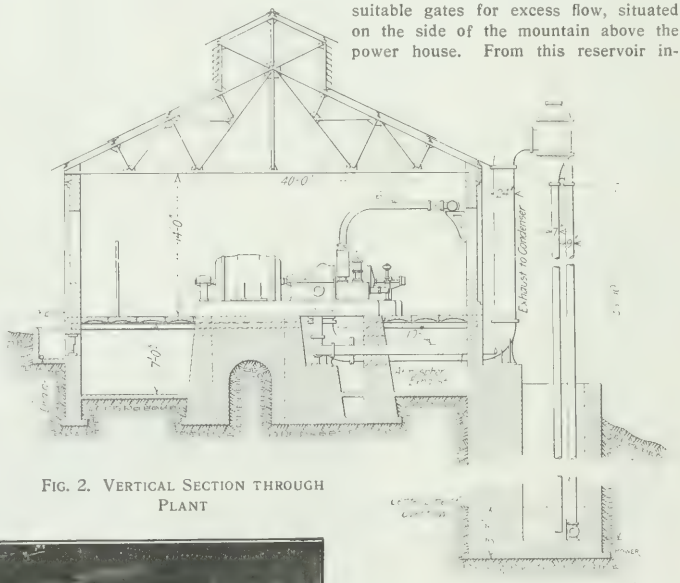


Fig. 2. Vertical Section through Plant

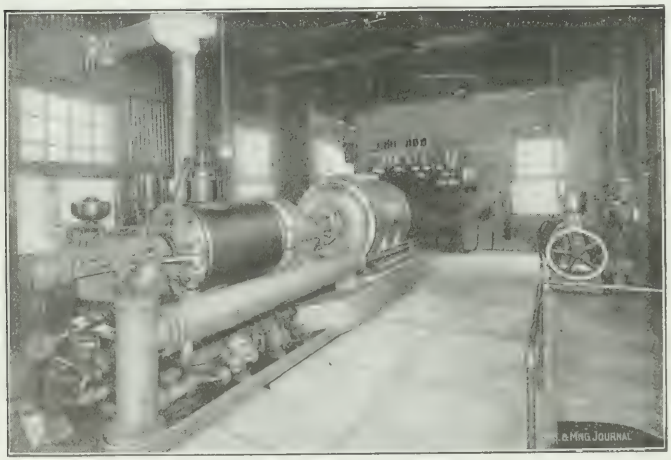


Fig. 1. Turbine Generating Unit in Power Plant

From the switchboard the alternating current generated is carried to the mine opening by means of a three-phase overhead line and thence through a three-conductor lead-covered steel-armored cable to the pump motors.

Starting the Motors

For convenience in operation, the engineers' plans provided for starting the

motors and stopping them directly from the power house. To this end induction-motor panels were embodied in the power-house switchboard, from which, by means of suitable gearing, are manipulated auto-starters situated in the basement. In addition, at each motor is provided an emergency oil switch, so that, in the event of an accident, the operator in the mine is not dependent upon the power-plant engineer to enable him to shut down. There is, however, direct telephone connection. In starting, a pump motor can be brought up to full speed quickly, with the other motor either running or shut down, and the momentary fluctuation in voltage is slight.

The underground pumping station and a permanent sump of 1,500,000 gal. or more are situated about 1600 ft. from the slope mouth. At this point the pumps have to operate against a total vertical head, including suction, of 655 ft. The rated capacity of each pump at 1130 r.p.m. is 1800 gal. per minute.

Electrically, there was some difficulty at the start. As is customary in systems containing a combination of overhead and underground circuits, high potentials occurred, due to resonance effects, which on several occasions produced pin-hole punctures in the insulation of the motor windings. This difficulty, however, was remedied by grounding the neutral point of the generator and installing aluminum-cell, electrolytic-type lightning-arresters.

For the illustrations and data here presented, the author is indebted to Jesse Adkins, Birmingham manager of Allis-Chalmers Co., which built the power and pumping machinery, and to F. W. Hausmann, engineer of the Sloss Sheffield Steel & Iron Co.

Answers to Study Questions

1. A horsepower is equal to 0.746 of a kilowatt. One pound of steam per kilowatt would be 0.746 of a pound per horsepower if the unit were of 100 per cent. efficiency. But if the unit had an efficiency of only 90 per cent., one horsepower would produce only

$$0.746 \times 0.90 = 0.6714 \text{ kw.}$$

One pound per kilowatt would therefore mean 0.6714 lb. per horsepower used in producing it under these conditions and 16.5 lb. per kilowatt-hour would mean

$$0.6714 \times 16.5 = 11.0781 \text{ lb. per hp.-hr.}$$

Proof: 11.0781 lb. of steam produce

$$746 \times 0.90 = 671.4 \text{ watts}$$

or

$$\frac{11.0781}{671.4} = 0.0165 \text{ lb.}$$

of steam produce 1 watt and

$$0.0165 \times 1000 = 16.5 \text{ lb.}$$

of steam produce 1000 watts or a kilowatt.

The formula is

$$\frac{W}{Hp.} = \frac{W}{Kw.} \times \frac{746E}{1000}$$

where

$\frac{W}{Hp.}$ = Water rate per horsepower;

$\frac{W}{Kw.}$ = Water rate per kilowatt;

E = Efficiency of the unit.

2. To produce a pound of dry saturated steam at 135 lb. pressure from water at 32 deg. requires 1191.6 B.t.u. (values are from the Marks-Davis steam tables).

To heat a pound of water from 32 to 160 deg. requires 127.86 B.t.u. To make the pound of steam from feed water of 160 deg. requires therefore

$$1191.6 - 127.86 = 1063.74 \text{ B.t.u.}$$

To evaporate a pound of water "from and at 212 deg.," that is, to evaporate at atmospheric pressure a pound of water already at the boiling point at that pressure, requires 970.4 B.t.u. Under these conditions, therefore, there would be evaporated by the same amount of heat

$$\frac{1063.74}{970.4} = 1.0962$$

times as much water as from feed of 160 into steam of 135 lb. pressure.

If, then, one pound of coal evaporates 8.5 lb. of water under the stated conditions, it would evaporate

$$8.5 \times 1.0962 = 9.3177$$

from and at 212 deg.

The formula is

$$E_e = E_a \frac{H - h}{970.4}$$

where

E_e = Equivalent evaporation from and at 212 deg.;

E_a = Actual evaporation under given condition;

H = Total heat of dry saturated steam of given pressure;

h = Heat of liquid at given feed-water temperature.

3. The product of each weight and its distance from the fulcrum or point over which the lever turns must be the same.

The given weight, 100 lb., is 9 ft. from the fulcrum. The product of the weight and distance is

$$100 \times 9 = 900$$

The missing weight multiplied by 3 must equal 900, then

$$900 \div 3 = 300$$

is the missing weight.

Proof:

$$100 \times 9 = 900$$
$$300 \times 3 = 900.$$

The formulas are

$$W = \frac{wD}{d} \qquad w = \frac{Wd}{D}$$

$$D = \frac{Wd}{w} \qquad d = \frac{wD}{W}$$

where

W = Greater weight;

w = Smaller weight;

D = Greater distance;

d = Lesser distance.

It makes no difference whether the distances are inches, feet or miles, so long as they are both taken in the same units.

4. One pound of force will accelerate the velocity of one pound of matter at the rate of 32.16 ft. per second.

For each pound of matter falling a pound of force is pulling downward.

Starting from rest, the velocity at the end of one second will be 32.16 ft. per second; at the end of 2 sec., 64.32, etc.

At the commencement of the first second the velocity is zero; at the end, 32.16 ft. per second. Since the acceleration is uniform the average velocity for the second will be

$$32.16 \div 2 = 16.08 \text{ ft. per sec.}$$

At the end of 4 sec. its velocity would be

$$4 \times 32.16 = 128.64$$

and its average velocity

$$128.64 \div 2 = 64.32 \text{ ft. per sec.}$$

Falling 4 sec. at this average velocity, it would drop through

$$4 \times 64.32 = 257.28 \text{ ft.}$$

The acceleration 32.16 ft. per second being that due to gravity is called g. Calling the time in seconds t and the distance d, the formula is

$$d = \frac{1}{2} g t^2$$

It would take 100 lb. per square inch *difference* in pressure between the contents of the boiler and the atmosphere to blow the valve wherever the boiler were. As the gage measures this difference of pressure, it would indicate the same pressure when the valve lifted whether the boiler were at sea level or on a mountain.

The N. E. L. A. *Bulletin* is asked if any member has been successful in securing power in laundries. If more power is sold to the average laundry, speaking for ourselves, the editorial force of this paper will have to seek refuge in overalls and jumper. Our newest negligee has shown a dangerous difference of potential between the primary and secondary "terminals," its dynamic force is well nigh spent, and it has the appearance of having been "shocked" beyond resuscitation.

Adjustment of Electric Lighting Rate

Extracts from the reports of the Wisconsin Railway Commission regarding the influence of various fixed charges upon the rates and a paper by Prof. Cory showing the influence of the load factor upon the total cost.

In estimating the costs of construction, operating expenses, depreciation, valuation, etc., of power plants and all factors to be considered in the establishment of equitable rates of services, the reports of the Wisconsin Railroad Commission have been almost universally adopted in principle by other state commissions, municipal public-utility boards and engineers as an accurate basis for decisions. Also, a recent address by Prof. Cory, of the University of California, upon the adjustment of rates, before the League of California Municipalities at Santa Barbara, offers new and instructive data. Before taking up Prof. Cory's paper, extracts will be given from the reports of the Wisconsin Railway Commission.

Wisconsin Railroad Commission—Valuation of Plants

Taxes, depreciation and interest on the investment are expenses which a public utility must meet; they should be borne by the consumer; otherwise the burden of cost does not fall where it belongs. Again, these so called "fixed expenses" depend directly upon the investment represented in the plant. To make each department bear its proper burden of expense, it is necessary to determine upon a fair valuation not only of the total property but of each department.

In estimating the costs for municipal as well as for privately owned plants, it seems necessary to consider the operating expenses, depreciation, taxes and interest on the investment. The two former are always present and must be met, no matter by whom the plants are operated. Taxes and interest charges may, in a sense, be dispensed with for municipal plants; on the other hand, both are evident in some form in all industrial activities. If such items as fixed charges are not considered by municipal plants in fixing rates for private consumers, it would seem that these consumers would be favored as against the tax payers. There does not, on the whole, appear to be any equitable ground upon which such charges can be entirely eliminated in any industry or in any connection with the services of any public utility.

Operating Expenses

Operating expenses may be divided into two classes: constant and variable expenses. Constant expenses are not often materially affected by the amount of business done, while variable expenses are affected by the amount of business done. From the point of view of rate making, since constant expenses depend upon the capacity, they should be distributed among the consumers, and since variable expenses depend on the output, they should be distributed according to the output. Under this apportionment, constant expenses assume the nature of a service charge and may either be directly applied as a service charge in the rates or may be used as the basis upon which to determine the minimum charge.

The electric-lighting business is such that a large proportion of the operating expenses are not directly proportional to the output. Since it is impossible to store electrical energy economically, the plant must be so designed and maintained as to be able to meet the maximum demand. Whether the consumer uses much or little current is of small consequence in determining the capacity of the plant. He has in his residence, store or office a certain number of lamps, and if he desires to burn all of them at one time, the plant must be able to supply him with sufficient current.

Variable expenses, including such items as fuel, oil, waste and certain repairs and labor, are directly proportional to the power sold; they increase as the output increases and decrease as it becomes less. There are, however, certain items which can be called neither all capacity expense nor all output expense, but must be divided between the two groups.

Distribution expenses are but slightly affected by output and are, therefore, largely capacity expenses; general expenses are entirely capacity costs, not influenced by output. Depreciation and interest on the investment are overhead expenses, following the general practice, and are apportioned between output and capacity on the basis of the total expenses. Direct expenses include the generation, distribution and consumption charges.

The practice of charging operating expenses to the construction account may have serious consequences. It may lead, first of all, to erroneous conclusions as to the financial condition of a plant and the sufficiency of the revenues derived from operation. If expenditures are wrongly charged to construction, operating expenses will appear correspondingly less, and the margin between revenues and expenses proportionately wider; and the showing of net profit augments fictitiously to an equal extent.

Depreciation

Depreciation is that loss or shrinkage of value which inevitably occurs from time to time in the equipment of the plant; it may be due to wear and tear, to age, to the march of modern invention or to inadequacy. The establishment of a depreciation fund, in short, is intended to keep the original investment intact. Bearing this in mind, depreciation might reasonably be defined as the amount which makes up the difference between the value of the plant at any period after construction, although kept in good running condition by ordinary repairs, and the original cost value of the plant.

Rate Establishment

The rates for electric energy should be based upon the cost of service, under which each particular consumer contributes to the revenues of the company in proportion to the cost to the plant of such service. The cost, in turn, depends upon the hours of daily operation and the rates must be based on the customer's daily use of this connected load. The actual rate in cents is dependent upon the facts in each case.

Every consumer calls into use a certain investment, regardless of the amount of his consumption. Even should he consume nothing, he would still have to be carried on the books and a certain amount of equipment would have to be held in readiness to serve him. Such fixed expenses properly constitute a definite consumer charge. In order that every consumer shall pay his share of the expenses, the expenses of the plant must be apportioned between the capacity and output costs, to determine what part of each class of expense should be charged against the consumer.

Prof. Cory's Paper

To apply the methods of obtaining approximately the cost of service to each consumer, along the lines indicated in the foregoing, the segregated costs, dealing separately with the fixed and variable expenses as affected by the load factor as well as the amount of electric energy used by each customer, have been worked out for two typical electrical lighting systems on the Pacific coast. These will be denoted as systems 1 and 2, the former having its power generated with steam, and the latter receiving its power at a substation outside of the city limits, stepping down from 60,000 volts to the voltage of commercial distribution.

Load Factor

Probably no point is of such serious consequence in connection with the operation of a municipal lighting system as the load factor, as most of the consumption is residence lighting, the period of use being usually not more than an average of two hours nightly out of the 24-hour day. Again, there is a wide difference between the maximum demand and the average load for the year, caused by the difference in the seasons.

As an illustration, Fig. 1 shows the load curve of system No. 2 on June 30, 1910, giving a maximum load of 1619 kw. at 9 p.m., and lasting but a brief interval. The average load for 24 hr.

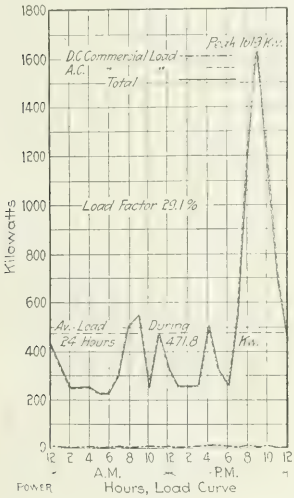


Fig. 1. Peak Load, Summer Months

was 471.8 kw., making a load factor of 29.1 per cent. for the day. Fig. 2 is the load curve of the same system six months later, on Dec. 31, 1910. The actual peak was 2363 kw., or almost 50 per cent. greater than on June 30. The load above 1200 kw. lasted for 5½ hr.; the average load for the 24 hr. was 920.7 kw., an increase of nearly 100 per cent. over that in June; and the load factor for the day was 38.9 per cent.

An annual load factor for such electric-lighting service of from 20 to 30 per cent. is not uncommon, while, in comparison, extensive transmission systems, often including a number of hydro-electric as well as steam-driven central stations, sometimes have a load factor of between 70 and 75 per cent. This, of course, is due to the extensive application of electric energy for power in the operation of transportation systems, industrial plants, mines, etc.

Plant Investments

Another point in connection with the construction and operation of municipally owned lighting systems, is the usual rapid growth of such systems; the increased investment demanded each year being met ordinarily by a new bond issue.

In the case of system No. 2, the additions varied from a minimum of $35,000 to a maximum of $120,000 per year; the total investment increasing in seven years from $155,000 to $565,000, approximately 3½ times the original outlay.

If there be a surplus under favorable conditions, it may be used for short periods to do needed construction work and

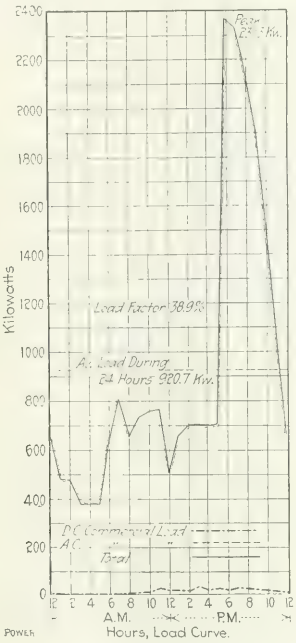


Fig. 2. Peak Load, Winter Months

later, the cost of such work may be met by a bond issue, reimbursing the surplus fund of the electric-lighting system. Also, in such cases it may be proper to expend for new construction, funds which properly must be set aside each year to cover depreciation, provided such accounts are always properly credited on the books of the system and the amounts replaced at such times as a new bond issue renders available such funds.

Fuel Cost

Figures by C. R. Weymouth have been used in determining the fuel cost at the switchboard of the steam plant per kilowatt-hour at various load factors. These are for condensing, direct-connected steam-driven units based on plants installed at Pacific coast railway-terminal points. The oil is assumed as having 18,850 B.t.u. per pound and weighing 336 lb. per barrel. The kilowatt-hours per barrel of oil from such source, for a 15,000-kw. condensing plant, operating 24 hr. per day, are:

Load Factor, Per Cent.	Kilowatt-hours per Barrel of Oil
100	197
50	155
33	125

The cost of fuel with oil at 70c. and also at $1 per barrel per kilowatt-hour, as affected by the load factor, is shown in Fig. 3. This indicates plainly the increased cost of fuel resulting from a low average daily load.

Plant Statistics

The figures given for the two particular electric-lighting systems selected

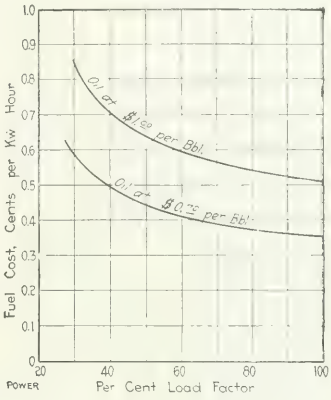


Fig. 3. Variation of Fuel Cost with Load Factor

are only relative, and do not indicate absolutely the average costs per kilowatt-hour, especially as delivered to consumers' meters, in other plants operating under entirely different conditions.

System No. 1

The relation between the investment per kilowatt in the generating stations, distributing system and electrical meters, based on the peak and the average load, is shown in Table 2, which clearly indicates the disadvantage of a low load factor.

In Table 3 the average rate of depreciation upon the generating station is taken at 5 per cent., so determined by considering separately the estimated life of the different parts of the station, inclusive of buildings, foundations and the steam and electrical machinery. The total generating cost per kilowatt-hour at the plant is less than one-half as much at 100 per cent. load factor as at 35 per cent. load factor, the actual fig-

TABLE 1

Item	System No. 1	System No. 2
Character of generating station	Steam plant	From water and steam power, transmission system
Cost of fuel per barrel	$1.00	
Installed capacity, kilowatts	1,750	
Peak load for year, kilowatts	1,200	[illegible]
Average load for year, kilowatts	415	750
Load factor for one year, per cent.	34.6	35
Efficiency of distribution system from switchboard to consumers' meters, per cent.	65	70
Aggregate length of distribution system, miles	75	overhead, 100 underground, 1.5
Average cost, distribution system per mile	$3,430	$3,050
Number of customers	3,057	7,250
Number of customers per mile of distribution system	41	69
Number of pole transformers	552	424
Aggregate capacity of transformers, kilowatts	2,179	4,167
Average capacity per transformer, kilowatts	4	10
Total valuation of system	$560,000	$577,000
Kilowatt-hours steam plant switchboard per year	3,635,500	
Kilowatt-hour, substation switchboard per year		6,570,000
Kilowatt-hours delivered to customers' meters per year	2,363,000	1,600,000
Average generating cost per kilowatt-hour, steam plant switchboard, cents	1.91	
Average generator cost per kilowatt-hour delivered to customers' meters, cents	2.94	
Cost per kilowatt-hour substation switchboard.		
100 per cent. load factor, cents		0.75
20 per cent. load factor, cents		2.25
Cost at substation switchboard per kilowatt-hour delivered to customers' meters:		
30 per cent. load factor, cents		3.21
Average total cost per kilowatt-hour delivered to customers' meters, cents	6.32	6.31

TABLE 2

Portion of System	Investment	Investment per Kilowatt: Installed Capacity	Peak Load	Average Load
Generating station	$253,000	$144.44	$210.65	$609.50
Distribution system	257,000	146.90	214.17	619.00
Electric meters	50,000	28.55	41.63	120.50
Total	$560,000	$319.89	$466.45	$1349.00

ures being 0.9c. per kilowatt-hour, with the best character of load and 1.91c. per kilowatt-hour, with the average load slightly above one-third the peak load.

TABLE 3 STATION CHARGES

Item	Yearly Total	Per Kilowatt-Hour: 100% Load Factor	70% Load Factor	35% Load Factor
Interest, 5 per cent.	$12,650	0.12	0.17	0.34
Taxes, 1.6 per cent	4,050	0.04	0.06	0.11
Depreciation, 5 per cent.	12,650	0.12	0.17	0.34
Fuel		0.51	0.56	0.79
Operation and maintenance	12,000	0.11	0.16	0.33
Total generating cost per kilowatt-hour at plant, cents		0.90	1.12	1.91
Total generating cost per kilowatt-hour delivered to customers' meters, cents		1.38	1.73	2.94

The annual depreciation for the distribution system, as given in Table 4, has been taken at 8½ per cent. It will be noted that the total distribution cost per kilowatt-hour delivered to customers' meters is nearly three times as great at 35 per cent. load factor as at the maximum load factor.

TABLE 4. DISTRIBUTION CHARGES

Item	Amount	Per Kilowatt-Hour: 100% Load Factor	70% Load Factor	35% Load Factor
Interest, 5 per cent	$12,850	0.12	0.17	0.35
Taxes, 1.6 per cent	4,120	0.04	0.06	0.11
Depreciation, 8.5 per cent.	21,850	0.21	0.30	0.59
Operation and maintenance	23,000	0.22	0.31	0.62
Total distribution cost per kilowatt-hour at plant, cents		0.59	0.84	1.67
Total distribution cost per kilowatt-hour delivered to customers' meters, cents.		0.91	1.29	2.57

In Tables 5 and 6 the total average cost per kilowatt-hour delivered to consumers' meters at 100 per cent., 70 per cent. and 35 per cent. load factor are 2.57c., 3.4c. and 6.32c. respectively, based upon the summations of the tables and including the total metering cost per kilowatt-hour delivered to customers' meters. These three comparative costs indicate why the consumer of electric energy, even though such consumption is reasonably small in magnitude, is justly entitled to a decidedly low rate if the electric energy used by him is utilized at a high daily average load; in other words, if his demand for service is such that the load factor is high. In this instance, if the load factor is uniform throughout the 24 hr., his rate may be properly 2.57c. per kilowatt-hour, increasing to 3.4c. if the average load is 70 per cent. of the maximum, and to 6.32c. if it is but 35 per cent.

TABLE 5 ANNUAL METERING, BILLING AND COLLECTING

Item	Amount	Per Kilowatt-Hour: 100% Load Factor	70% Load Factor	35% Load Factor
Interest 5 per cent	$2,500	0.02	0.03	0.07
Taxes, 1.6 per cent	800	0.01	0.01	0.02
Depreciation, 8 per cent.	4,000	0.04	0.05	0.11
Operation and maintenance	12,000	0.11	0.16	0.33
Total metering cost per kilowatt-hour at plant		0.18	0.25	0.53
Total metering cost per kilowatt-hour delivered to customers' meters		0.28	0.38	0.81

TABLE 6. TOTAL COST OF ELECTRIC SERVICE PER KILOWATT-HOUR TO CUSTOMERS' METERS AT DIFFERENT LOAD FACTORS

Item	Per Kilowatt-Hour to Customer at: 100% Load Factor	70% Load Factor	35% Load Factor
Generation, cents	1.38	1.73	2.94
Distribution, cents	0.91	1.29	2.57
Metering, cents	0.28	0.38	0.81
Total cost (average), cents	2.57	3.40	6.32

SYSTEM NO. 2

The total investment in system No. 2 and the investment per kilowatt-hour peak and average yearly load is shown in Tables 7 and 8. From these figures it will be noted that the total investment per kilowatt for the average load in this system is only a little more than one-half the corresponding investment in system No. 1, due to the fact that no investment is required for the generating station in system No. 2.

TABLE 7 TOTAL INVESTMENT

Substation:		
Real estate	$22,000	
Buildings	33,500	
Apparatus	87,500	$143,000
Distribution:		
Overhead	274,500	
Underground	44,000	318,500
Meters		115,500
Totals		$577,000

TABLE 8. INVESTMENT IN SUBSTATION, DISTRIBUTION SYSTEM AND ELECTRICAL METERS PER KILOWATT-HOUR PEAK AND AVERAGE YEARLY LOAD

	Total Investment	Investment per Kilowatt: Peak Load, 2500 Kilowatts	Investment per Kilowatt: Average Load, 750 Kilowatts
Substation	$143,000	$57.20	$190.60
Distribution	318,500	127.50	424.70
Meters	115,500	46.20	153.90
Total	$577,000	$230.90	$769.20

Table 9 shows the distribution cost per kilowatt-hour delivered to customers' meters at 100 per cent. load factor.

In Table 10 are given the annual metering, billing and collecting costs per kilowatt-hour on the substation switchboard and at the consumers' meters for different load factors.

In system No. 2 the cost of electrical energy from the transmission lines represents an average monthly cost to the customer of $1.70; the corresponding distribution cost, $1.15, and the cost of metering, etc., 49c., amounting to a total average monthly cost per customer of $3.34. Comparing Table 6 with Table 11, which gives the total cost of electric service per kilowatt-hour to the customers' meters, it will be noticed that the average monthly cost per customer is less in system No. 2 than in system No. 1, because of the greater number of meter connections.

TABLE 9. ANNUAL DISTRIBUTION CHARGES AND COST PER KILOWATT-HOUR ON SWITCHBOARD AND AT CUSTOMERS' METERS FOR DIFFERENT LOAD FACTORS

Item	Amount	Per Cent.	Yearly Charge	100 Miles of Distribution System: 100%	70%	30%
Interest	$461,000	5	$23,050	0.11c.	0.15c.	0.35c.
Taxes	461,000	1.6	7,376	0.03c.	0.05c.	0.11c.
Depreciation:						
Buildings	33,500	3	1,005			
Electrical apparatus	87,500	5	4,375			
Distribution, overhead	274,500	8½	23,333			
Distribution, underground	44,000	4	1,760			
	$439,500	6.94	$30,473	0.14c.	0.20c.	0.46c.
Operation and maintenance			40,000	0.18c.	0.26c.	0.61c.
Total distribution cost per kilowatt-hour at substation				0.46c.	0.66c.	1.53c.
Total distribution cost per kilowatt-hour delivered to customers' meters				0.66c.	0.94c.	2.19c.

TABLE 10. ANNUAL METERING, BILLING AND COLLECTING, ETC., CHARGES

Item	Amount	Per Cent.	Yearly Charge	Cost per Kilowatt-hour: 100%	70%	30%
Interest	$115,500	5	$5,775	0.03c.	0.04c.	0.09c.
Taxes	115,500	1.5	1,850	0.01c.	0.01c.	0.03c.
Depreciation	115,500	7	9,240	0.04c.	0.06c.	0.14c.
Operation and maintenance			26,000	0.12c.	0.17c.	0.40c.
Total metering cost per kilowatt-hour at substation				0.20c.	0.28c.	0.66c.
Total metering cost per kilowatt-hour delivered to customers' meters				0.28c.	0.40c.	0.94c.

TABLE 11. TOTAL COST OF ELECTRIC SERVICE PER KILOWATT-HOUR TO CUSTOMERS' METERS AT DIFFERENT LOAD FACTORS

Item	Per Kilowatt-hour to Customer at: 100% Load Factor	70% Load Factor	30% Load Factor
Cost of power at substation	1.07c.	1.50c.	3.21c.
Distribution	0.66c.	0.94c.	2.19c.
Metering	0.26c.	0.40c.	0.94c.
Total	1.99c.	2.84c.	6.34c.

Condenser Head Broken by the Gasket

By W. G. Freer

A few years ago it became necessary to remove the head from a condenser in a large central station, for the purpose of cleaning the tubes. The condenser was in two sections, each probably 50 in. inside diameter, with flanges at the end about 1 in. on the radius. The head was about 1 in. thick, of cast iron, and dished considerably to stiffen it. The dishing sprang from the inner edge of the flange, and was sharp and clearly defined, the flat border being of the same width as the flange on the cylinder.

On removing the head the gasket stuck and was broken, making it unfit for further use. When the head was about to be replaced it was found that there was not sufficient sheet packing to make a gasket, and, as a substitute, a soft piece of rubber gas tubing was laid on the flange just inside of the bolts, and the ends lapped, making what is commonly called an inside joint. The head was bolted on and the pump started, to test the job, which appeared to be all right, and the engine was reported ready for service.

This being a night watch job, the engine was not ordered on the line until the next afternoon, when, as the station load increased, it was brought up to speed and the load thrown on as usual.

Shortly after this the engineer on watch made a tour around the plant, and upon reaching the condenser he saw water flowing down over the outside of the head. Upon closer examination he discovered that it was coming from a crack which extended for some 18 or 20 in. along the inner circle of the flange. He immediately stopped the circulating pump and opened the exhaust to the atmosphere, as the engine was capable of carrying the load when running noncondensing.

The fracture was reported and an investigation held to determine the cause and place the blame. The evidence all tended to prove that due care had been exercised in screwing the bolts gradually and equally all around, and as the head was generally thought to be tight, it was about to be declared an unavoidable accident, due to poor design, when one of the engineers suggested that the gasket had been the cause of the trouble. He was directed to explain, and, as he had been in charge of the job and was the man to bear the blame for any mistake, considerable interest was manifested in what he had to say.

He pointed out that the narrow gasket in its position close to the bolts, placed the head in the class with a beam supported at the ends and uniformly loaded. The old gasket had been of sheet packing which was almost entirely of canvas, and hard, covering the full width of the flange. He claimed that the head on this seating was in the class with a beam rigidly fixed at both ends, a much stronger construction.

This line of reasoning was followed by the chief stating that he had noticed that the head appeared to spring slightly more to the pulsations of the pump than usual, when the job was tested, but that he had become so accustomed to seeing the head breathing that he had passed it as imaginary and had not given it the careful consideration that it would have received had it been a new condition.

The investigation ended here and nothing happened to the men at fault, but the problem was discussed by the engineers and foremen and all came to the conclusion that the gasket was the cause. Inside joints are all right, but one should be sure the head is strong enough. If there is any doubt of this, a full flange joint should be used; it is stronger.

The Kienast Steam Turbine

Description and results of tests on the Kienast steam turbine. In this type the blading on the wheel is so arranged as to provide three concentric passages for the steam; that is, the steam passes axially through the blading and by means of reversing passages is returned and made to act upon the same wheel three times.

The machine is adapted especially to the smaller capacities.

This is one of those turbines, adapted especially to smaller capacities, in which the steam is made to act a number of times successively upon the same wheel by being passed across it axially through the blading and returned by reversing passages to act again upon the blading from the opposite side. The peculiarity of the Kienast system is that the blading is divided radially into a number of chambers, usually three, by fins inserted into the concave inner faces of the blades, as shown in Fig. 1. The turbine is of the partial-admission type, the outlet of the admis-

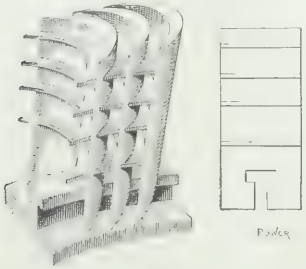
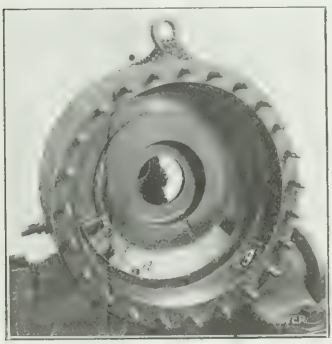
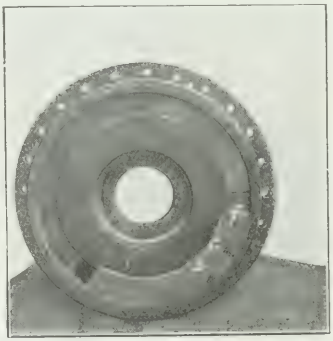


FIG. 1. METHOD OF ATTACHING BLADES.

sion nozzles being shown at *a* in Fig. 2. In this nozzle, shown also at *a* in Fig. 4, the steam is expanded from the initial to the back pressure, and with the velocity thus acquired impinges upon the wheel, which absorbs some of its energy and discharges it at a reduced velocity into the port *b*, Fig. 3, shown diagrammatically at *b*, Fig. 4. The width of this





FIGS. 2 AND 3. SHOWING STEAM PASSAGES IN CASING

nozzle is sufficient to span only the first or outer division of the blade, as shown in the section *AA*, Fig. 4, but the reversing passage, of which *b* is the entrance, increases in depth as it progresses until at its exit, *c*, Figs. 3 and 4, it spans two of the divisions, as shown in the section *BB*, Fig. 4. There is no expansion into this increased volume as the steam has been already expanded to the counterpressure; but the increased cross-section permits the passage of the same volume of steam at the diminished velocity. The reversing passage connecting the ports *d* and *e* deepens progressively until at its exit *e*, section *CC*, Fig. 4, it spans all three divisions. By its final impact the velocity of the jet is reduced so that the residual energy which it contains is unimportant and it is discharged at *f* into the case and escapes through the exhaust passage *g*, Fig. 2.

Fig. 5 is a horizontal and Fig. 6 a vertical section through one of the earlier turbines of 50 hp. capacity. The wheel *W* was at that time made by clamping the blades between chrome-steel disks riveted together as shown, but the blades in the later construction have T-slots at their lower extremities and are strung upon a disk having a corresponding T-rail upon its periphery as shown in Fig. 1. The turbine shown has two sets of nozzles, *NN*, Fig. 5. There is, however, no general high-pressure steam chamber attached to or forming a part of the case. Steam is admitted through the throttle valve *H* and the governor to the chamber *J* connecting with the nozzle *N*, and is taken from this chamber by means of the pipe *K* passing under the turbine to the nozzle chest *L* supplying the other nozzle. For light loads this nozzle may be shut off by means of the valve *M*. The absence of any large chamber under high pressure and temperature avoids distortion of the case due to unequal expansion, the steam not being admitted beyond the small valve chests until after it has been expanded to the terminal pressure and temperature. In addition to the main governor, best seen in Fig. 7,

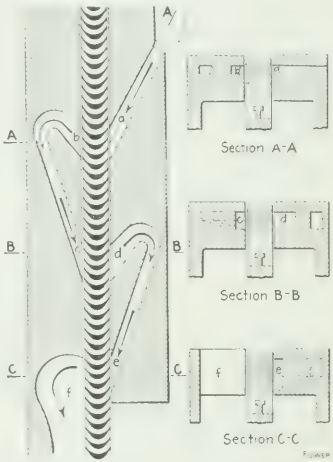


FIG. 4. INDICATING THE PATH OF THE STEAM

there is the usual safety stop *S*, Figs. 5 and 6.

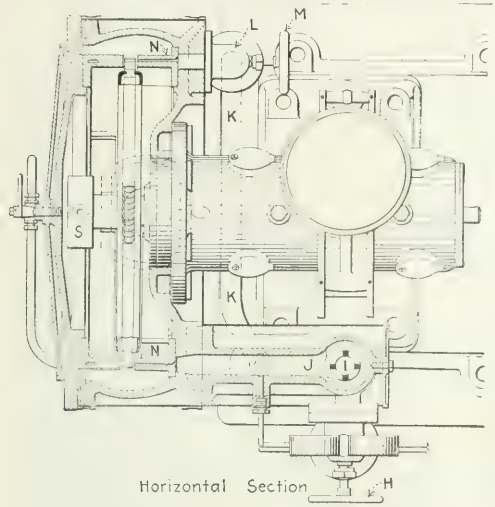
The blades and shaft are made of hard chrome-nickel steel, that for the blades being extruded in the desired crescent-shaped section, cut into lengths and slotted for the partitions. The nozzles are pressed into shape out of sheet steel, while the reversing passages are made in two parts out of pressed delta metal. The clearance axially, that is, between the nozzles and the blades, is 4 mm. (about 0.16 in.).

This system is best adapted for the high-pressure ranges of the expansion. The impracticability of making the reversing passages above a given size places an early limit upon the capacity which they can take care of when the volume of steam is increased by expansion to the low absolute pressures used with condensing turbines. For the lower-pressure stages it is necessary, therefore, to use additional wheels, but even in these the partitions in the blading are retained as tending to prevent the formation of secondary currents and to reduce windage. Fig. 8 shows a portion of one of the larger wheels of late construction.

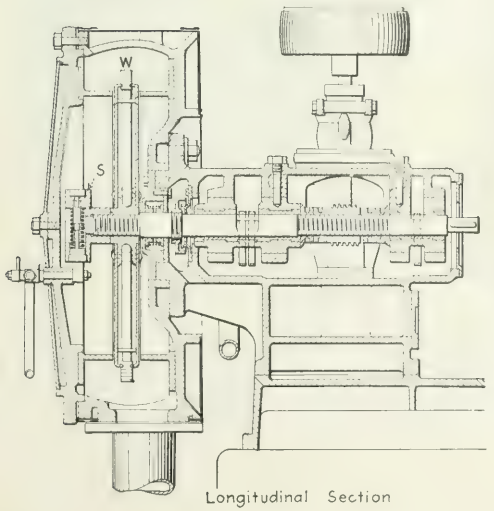
In the spring of 1910, a 35-hp. turbine of this type built by Beige & Kuenzli, at

RESULTS OF STEAM CONSUMPTION TESTS

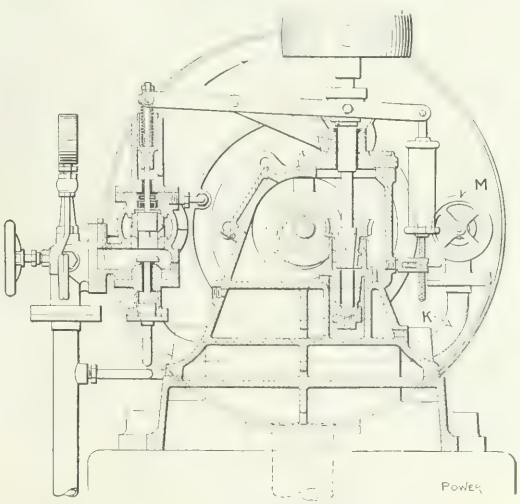
Number of Test	Steam Condensed, Lb. per Hr.	Internal Pressure, Lb. per Sq.In. Abs.	Initial Temperature, Degrees Fahrenheit	Saturated Steam Temperature, Deg. F.	Superheat, Deg. F.	Final Pressure, Lb. per Sq.In.	Final Temperature, Degrees Fahrenheit	Effective Turning Moment, Ft.-Lb.	R.p.m.	B.hp	Weight of Steam, Lb. per Hr.	Stuffing-box Leakage, Pounds per Hour	Working Steam, Lb. per Hr.	Steam per B.hp.-hr.	Steam Required by Engine of 100% Efficiency per B.hp.	Rankine Efficiency.	Duration of Tests, Min.
1	279.35	28.44	256.46	247.28	9.18	14.57	208.4	0	2887	0	244.64	34.71	244 64	....	0		60
2	1210 85	149.05	480.2	357.62	122.58	14.67	309.38	59.31	2933	33.20	1190.16	5.06	1190 16	34.86	13.19	0.378	60
3	1375 29	167 97	505.4	367.16	118.24	14.64	325.40	72.33	2835	39.12	1325.70		1325.70	32.95	12.49	0.379	60
4	631 75	75 23	311.36	307.58	3.78	14.79	210.2	15.47	3063	9.13	...		631.75	67.60	.	.	30
5	935 81	121 03	341.6	341.6	0	14.79	210.2	34.71	3061.5	20.38	...		935.81	44.65	.		30
6	1229 61	169.53	369.32	367 88	1.44	14.79	210.56	54.82	2994	31.31	...		1229.61	38.21	....		15
7	217.31	33.42	342.5	256 28	86.22	14.64	293.0	0	3057.2	0	240.23		217.31			0	30
8	622.40	83.91	396.14	314.96	81.18	14.64	361.22	20.10	3057.2	11.80	573.04	49.36	573.04	47.28	17.41	0.368	30
9	866 17	126.30	482.9	344.84	138.0	14.64	320.0	37.97	3047.2	22.13	840.82	25.34	840.82	36.95	14.23	0.385	30
10	1159.30	166.83	493.34	366.62	126.72	14.64	311.36	57.86	3014.4	33.27	1109.71	49.59	1109.71	32.43	12.67	0.391	40
11	1132.85	167.68	528.44	366 98	161.46	14.64	316.28	57.50	3072.3	33.72	1090.98	41.87	1090.98	31.52	12.36	0.392	40
12	1106.40	167.54	441.32	366 89	74.52	14.64	388.4	69.43	1997.1	26 42	1102.0	4.40	1102	40.60	12.49	0.308	30
13	1086.57	164.70	442.22	365 54	76.68	14.64	374.0	58.94	2744	30 86	1075.55	11 02	1075 55	33 91	12.49	0.369	45
14	1115.22	167.54	442.76	366 89	76.0	14.64	367.16	58.58	3000	33.55	1093.18	22.04	1093 18	31 69	12.39	0.391	15
15	...	167.83	501.44	367.07	134.46	14.64	318.56	56.92	3150	34.26	1110.81		1110 81	31.52	12.60	0.40	5
16	...	167.83	505.04	367.07	138.0	14.64		56.05	3260	34.92	1108.61		1108 61	30 86	12.54	0.406	5
17	1112.13	167.54	443 18	366.89	76.68	14.64	369.14	55.69	3330	35.46	1086.57	25 56	1086 57	29 82	12.32	0.413	10
18	1105.30	167.12	502.16	366 71	135.54	27.91	400.28	40 36	3018.4	23.29	1105.30	0	1105 30	46 12	16.28	0.353	25
19	1099.79	169.11	503 78	368 06	135.72	40.49	410.0	27.48	2988.6	15.75	1113.02	0	1099.79	67 93	19.69	0.290	30
20	1094.50	167.54	515 30	366.89	148.50	14.61	500.0	94.17	0	0	1094.50	0	1094.50			0	90



Horizontal Section



Longitudinal Section



Cross Section

FIGS. 5, 6 AND 7. SHOWING SECTIONAL VIEWS OF THE KIENAST TURBINE

Taucha, near Leipzig, was tested by Prof. Josse in the mechanical laboratory of the Royal Technical College of Charlotten-

FIG. 8. PORTION OF WHEEL

burg, at Berlin, the results of and deductions from which are compiled in the ac-

companying table. In the first three tests the turbine was equipped with a nozzle having a cross-section of 105 mm². (0.16 sq.in.). The weighed condensate amounted to more than would be discharged through a nozzle of this size and it was concluded that water from the stuffing-boxes had entered the turbine and mingled with it. The weights given in the table are, therefore, the computed weights and not those obtained from the scales. The rest of the tests were made with a nozzle having a minimum cross-section of 87.5 mm². (about 0.136 sq.in.).

Test 20 was made with the turbine standing still and the water turned off from the bearings to verify the correctness of the calculation for nozzle discharge. The quantities of condensate differed from the calculated values less than 1 per cent. on an average. On test 7, however, the quantity of steam obtained by calculation was greater than that obtained by measurement. The turbine had been running with full load and it is suggested that the steam took up heat from the metal at a greater temperature than that observed.

American patents have just been secured and are in the hands of G. A. Crayen & Co., 81 New St., New York City, for disposal.

Balanced Draft Furnace Regulation

By Warren O. Rogers

A system for maintaining atmospheric pressure in a boiler furnace.

The air delivered to the furnace is automatically controlled, also the gases escaping to the atmosphere, the former by the pressure built up in the furnace.

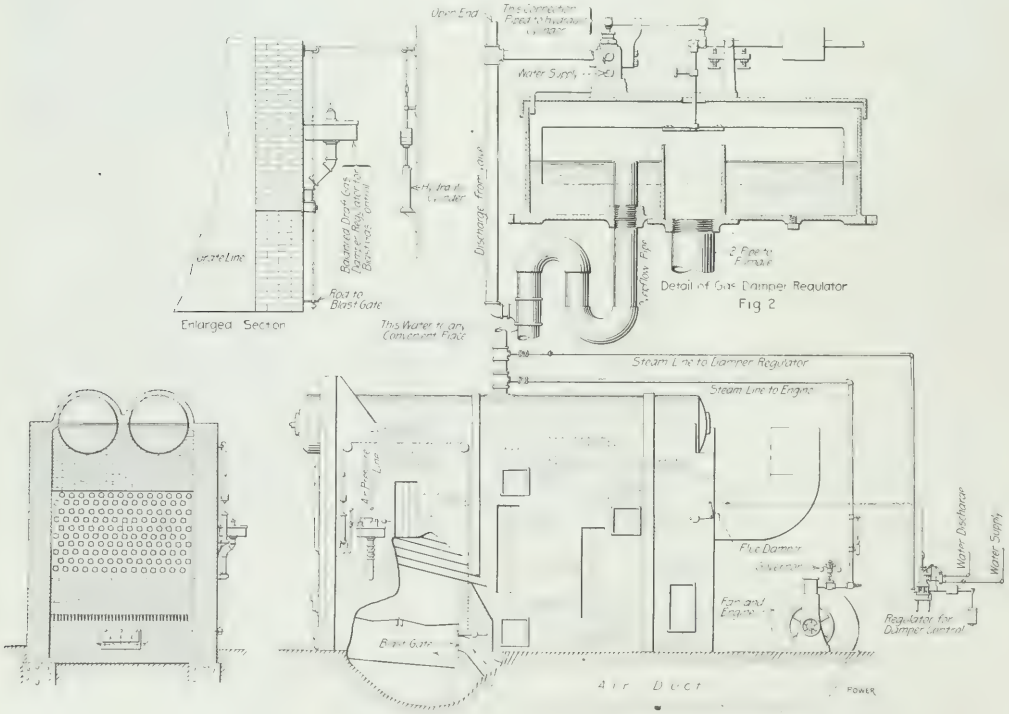
If you were to go into a boiler room and hear the term "balanced draft" used, would you know what was meant, what it accomplished, and why one would think of installing the necessary apparatus for maintaining it?

Under natural conditions, the draft in a chimney is maintained by the difference in temperature between the gases of combustion on the interior of the chimney and the temperature of the air on the exterior. As the hot gases pass to the stack, air is drawn into the partial vacuum thus formed in the furnace, and in passing through the fuel produces combustion. Why, then, should artificial means be used to produce similar results?

The ideal furnace condition is that of supplying just the amount of air necessary for complete combustion of the fuel, but natural draft will not produce this condition, and that is why artificial means are employed.

Balanced draft is a method of operating a furnace by which the exhaust gases from and the supply of air to the furnace are so automatically controlled as to bear a fixed relation to each other, so that a substantially uniform pressure is maintained in the furnace for varying rates of combustion.

Improper combustion is responsible for much of the avoidable losses of heat units in the furnace. If enough air is not supplied, a high-grade fuel must be burned, the fires must be cleaned frequently in order to reduce the resistance to the air in passing up through the grates and fuel, a low rate of combus-



FIGS. 1 AND 2. ARRANGEMENT OF BALANCED DRAFT SYSTEM AND DETAILS OF GAS DAMPER REGULATOR

tion will take place and losses of heat due to the formation of carbon-monoxide gas will occur.

If the draft is too strong, more air than is needed is supplied, and the excess air reduces the temperature of the furnace.

It is to overcome these two extremes of air supplied to a furnace that balanced draft is used, for the fundamental principle of balanced-draft control is that of maintaining in the furnace chamber, at the furnace door, a pressure which will equal that of the atmosphere. This results in a substantially higher CO_2, a higher and more even temperature in the furnace and lower flue-gas temperatures.

Another feature other than the advantage obtained in economy and efficiency is the reduction in the cost of upkeep of the boilers and boiler setting. This is because cold air drawn into the furnace during the time of firing is eliminated, thereby preventing the constant expansion and contraction due to cold air being taken into the furnace when firing under ordinary conditions; thus permitting of much longer life to both the boiler and the settings. In case the chimney of a plant is insufficient, the balanced-draft condition increases its capacity; in some cases it is claimed to be as high as 50 per cent.

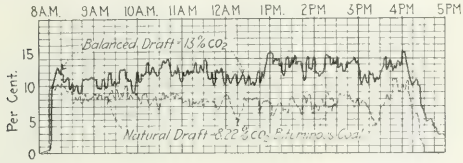


FIG. 3. COMPARISON OF FLUE GASES WITH NATURAL AND BALANCED DRAFT

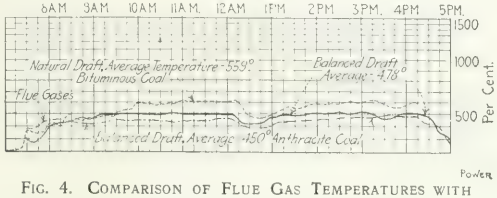


FIG. 4. COMPARISON OF FLUE GAS TEMPERATURES WITH NATURAL AND BALANCED DRAFT AT BASE OF STACK

In Fig. 1 is shown a typical application of the balanced-draft system of furnace regulation on a horizontal, water-tube boiler, as manufactured and installed by the Engineer Co., 50 Church St., New York City. By this system of regulation an individualism of the boiler unit is obtained. Each boiler is operated with respect to the particular condition existing in each unit, and each is made to do its *pro rata* share of the total output of the plant. The air supplied to each boiler is maintained with respect to the thickness of the fuel bed, so that the boiler furnace with a thin fire does not get an excess of air over the adjoining furnaces which may have thick fires.

FIG. 5. SHOWING THE BALANCED CONDITION OF THE FURNACE

This control also compensates exceedingly well for blow-holes in the fuel bed, which are common occurrences in some furnaces, by cutting down the air supply when such conditions exist and preventing the loss in furnace efficiency which would otherwise result.

APPARATUS USED

The apparatus necessary to produce balanced draft is a positive pressure type blower to furnish air to the boiler furnace; a special type of steam damper regulator connected to and operating the flue damper of each boiler, and a special type of balanced-draft gas damper controller connected to and operating the blast gate in the ashpit.

The engine operating the blower is regulated by a ball governor, the blower running at approximately constant speed. The blower delivers air to the main air duct at a constant pressure and volume.

GAS DAMPER

The gas damper, a sectional view of which is shown in Fig. 2, is a simple piece of mechanism and is operated by the air pressure in the furnace. It consists of an outer casing, in which an inverted pan is placed, attached to a counter-weight lever, and by means of a link and lever operates the valve controlling the water supply to the hydraulic cylinder, the plunger of which operates the blast gate. The water in the body of the gas damper is kept at a constant level by the addition of a small amount which flows into it from the water

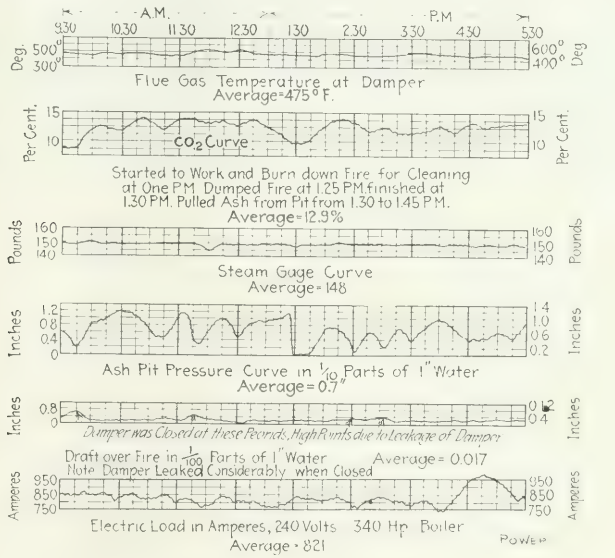

A.M. P.M.
9.30 10.30 11.30 12.30 1.30 2.30 3.30 4.30 5.30
Deg. 500° 300° 600° 400° Deg.
Flue Gas Temperature at Damper
Average=475° F.
Per Cent. 15 10 CO2 Curve 15 10 Per Cent.
Started to Work and Burn down Fire for Cleaning at One P.M. Dumped Fire at 1.25 P.M. finished at 1.30 P.M. Pulled Ash from Pit from 1.30 to 1.45 P.M.
Average=12.9%
Pounds 160 150 140
Steam Gage Curve
Average=148
Inches 1.2 0.8 0.4 0
Ash Pit Pressure Curve in 1/10 Parts of 1" Water
Average=0.7
Inches 0.8 0
Damper was Closed at these Periods. High Points due to Leakage of Damper
Draft over Fire in 1/100 Parts of 1" Water Average=0.017
Note Damper Leaked Considerably when Closed
Amperes 950 850 750
Electric Load in Amperes, 240 Volts 340 Hp Boiler
Average=821
POWER

FIG. 6. PRESSURE AND TEMPERATURE CHARTS OBTAINED WITH BALANCED DRAFT

alve. The excess water goes to waste hrough the overflow pipe. Connection s made to the boiler furnace by means of the central connection, which extends up into the inverted pan a suitable dis-ance above the water level.

Operation of System

As the steam pressure reaches a pre-determined pressure, the damper regu-ator closes the damper in the smoke flue, which increases the air pressure in he furnace, and the floating pan in

Temperature and CO_2 Charts

In Fig. 3 is shown a chart which gives a comparison of the flue gases with natural and balanced draft, the chart line representing the percentage of CO_2 in the flue gases.

The chart shown in Fig. 4 is a comparison of the temperature of the flue gases at the base of the stack with natural and balanced draft, the former averaging 559 deg. F., the latter 450 deg. F. As a test of the actual furnace conditions a handkerchief was suspended

Exploding Tank Wrecks Building

The accompanying illustrations were taken of the wrecked building of the Hine Bros. Soap Works, 4023 South Ashland Ave., Chicago, Ill., which was the result of the explosion of a rendering tank early Wednesday morning, Feb. 28.

This tank was used for rendering grease from garbage, which was treated under steam to recover the soap grease. Two men were slightly injured.

Fig. 1. Ruins of Building after Tank Exploded

he gas damper is lifted. This action uts off the water supply to the hy-draulic plunger operating the blast gate, nd the weight on the plunger rod orces the plunger down and pulls p on the lever of the blast gate, which closes the air inlet of the air duct. This shuts off the supply of air to the urnace coming from the fan.

As the steam pressure drops, a reverse ction takes place. The damper regu-ator opens the flue damper, which de-reases the air pressure in the furnace, nd the floating diaphragm in the gas amper lowers, causing the water valve o open. The water pressure then forces he piston of the hydraulic cylinder up nd the weight on the arm of the blast ate opens the gate and admits the air rom the air duct into the furnace. As hese operations are taking place con-inuously, the steam is thus maintained t a constant pressure. All of the vari-us controllers are always in such rela-ion to one another that any predeter-mined atmospheric pressure may be maintained for all rates of combustion at he furnace door.

at the furnace door, with the boiler being worked far in excess of its rated capacity, without there being any deflection of the handkerchief in either direction. This is illustrated in Fig. 5 and shows that there is no draft, as generally understood, or current of air passing into or out of the furnace through the furnace door. It is a practical illustration of a balanced-draft condition for a boiler furnace; the view was taken in the boiler room of a large steam plant.

The charts shown in Fig. 6 were taken at the Singer Building power plant, New York City, and show the temperature of the flue gases at the damper, with an average of 475 deg. F. The CO_2 curve shows an average of 12.9 per cent. The steam record, with one or two exceptions, was practically straight, the average pressure being 148 lb. per square inch. The ashpit pressure curve shows 0.7 in., and the draft over the fire averages 0.017 in. The damper leaked when closed, which accounts for the irregularity at the points indicated by the arrows. The average electrical load in amperes was 821 and the load was carried by 340 hp. in boiler capacity.

The tank was 72 in. by 14 ft. and was made of $\frac{3}{8}$-in. steel. The contents were digested under a steam pressure of 50 lb. per square inch. Fig. 1 shows a view of the wrecked building, and one of the remaining rendering tanks.

From information received from a Western correspondent, it is learned that last June another tank in this plant had been condemned by the Chicago city boiler-inspection department, and that the exploded tank was reported in bad shape and good only for about three months of service. A new tank was on the ground ready to replace the one which had been condemned.

After the explosion the safety valve of the tank was found and under test it blew at 51 lb., indicating that excess pressure was not the cause of the explosion; deterioration of the plates is the true explanation. The life of one of these tanks is said to be not more than four years, owing probably to the acidic properties of the contents.

A close examination of the tank in Fig. 1 shows that the middle sheet was riveted on the inside of the two outside end sheets. This is faulty construction,

as in this kind of work the acids which form from the garbage get in between the outer and inner sheets above the riveted joints. Had the middle sheet been riveted to the outside of the two end plates this action would have been retarded, as the acids and moisture would have collected

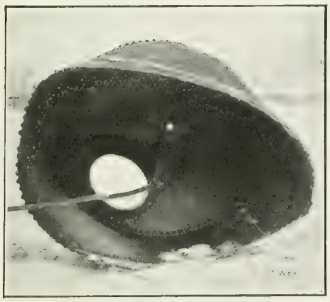


FIG. 2. TOP SHEET OF TANK SHOWING RUPTURE BELOW THE RIVETED JOINT

on the upper plate and dropped off without lodging in the joint.

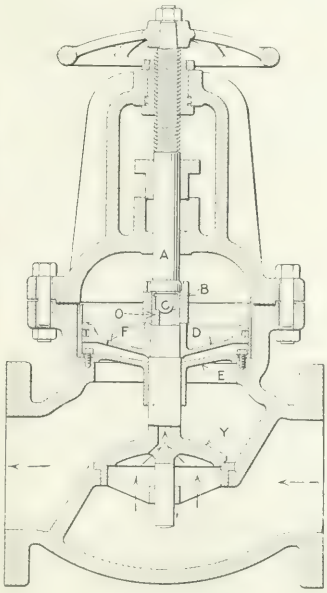
In Fig. 2 is shown the top section of the tank, also the corroded condition of the second sheet, which gave way just below the riveted joint. A comparison of the outer and inner sheets can be made at the right-hand side of the illustration.

Golden-Anderson Automatic Valves

The value of an operable safety device in an emergency need hardly be dwelt upon. Many a serious boiler explosion might have been avoided by a nonreturn valve, and many an engine runaway might have been stopped before a destructive speed was reached had an emergency stop valve been a part of the equipment. The purchase of such automatic safety appliances is superior to the buying of accident insurance, as the former means money spent in preventing accidents and not in wagering that they will happen.

The valve illustrated in Fig. 1 is the Golden cushion triple-acting nonreturn valve. Besides acting as an automatic nonreturn valve, it also acts as an automatic safety stop. In addition to this, the valve may be operated by hand, by electricity from remote points and by steam. Inserted in a pipe connecting the boiler and header, it will automatically close in case the pressure in the boiler drops suddenly, because of a ruptured tube, etc. On the other hand, the valve will also close automatically if a sudden drop in pressure occurs on the delivery side of the valve.

As shown in Fig. 1, the valve is in the closed position, having been closed by hand. The spindle *A* is not attached to the valve part *B*, but simply bears on it when the valve has been closed or partly closed by hand. At other times, the spindle is clear of the part *B* and steam



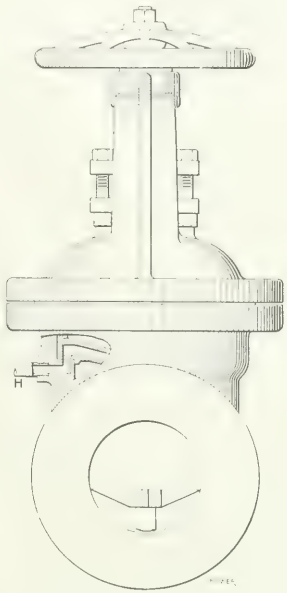


FIG. 1. GOLDEN CUSHION TRIPLE-ACTING NON-RETURN VALVE

from the inlet side of the valve is free to raise the ball *C* from its seat and fill the space above the diaphragm *D*, and also the space between *D* and *E*, through

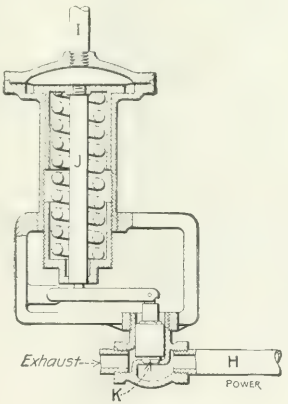


FIG. 2. PILOT VALVE

the port *F*. The diaphragm *D* is integral and moves with the main valve part *B*, while *E* is held in a fixed position by cap screws as shown. As the pressure on both sides of the diaphragm *D* is the same, the pressure of the steam acting on the under side of *Y* opens the valve and keeps it open as long as there is any flow of steam. The instant the flow ceases or reverses its direction the valve closes of its own weight.

Communicating with the space between the diaphragms by means of the pipe *H*, is the pilot valve shown in Fig. 2. The space above the pilot-valve diaphragm communicates with some point in the pipe system on the discharge side of the main valve, by means of the pipe *I*. If the pressure in the pipe *I* drops for any reason, the spring raises the rod *J*, and opens the pilot valve *K*.

As the area of the opening in the pilot valve and pipe *H* is considerably larger than the area in the port *F*, Fig. 1, in the diaphragm *D*, the opening of the pilot valve reduces the pressure in the space between the diaphragms *D* and *E*, and the full inlet pressure acting against the upper surface of *D* closes the valve and keeps it closed because the total effective pressure on *D* is greater than that on the under side of *Y*. Thus, as long as the pilot valve remains open the main valve must remain closed. By adjusting the spring on the pilot valve, the main valve can be made to close when the drop in pressure exceeds any predetermined amount.

If desired, another pilot valve *L*, Fig. 3, is connected to the pipe *H*, as at *M*, this second pilot valve being controlled by a solenoid. Then the main valve may be closed electrically from as many points as desired.

THROTTLE VALVE AND AUTOMATIC ENGINE STOP

The valve shown in Fig. 4 is especially designed as a throttle and automatic en-

ine stop valve, the principle of operation being the same as that of the valve ust described. The spring *N* holds the alve part *O* up off the seat during nor-

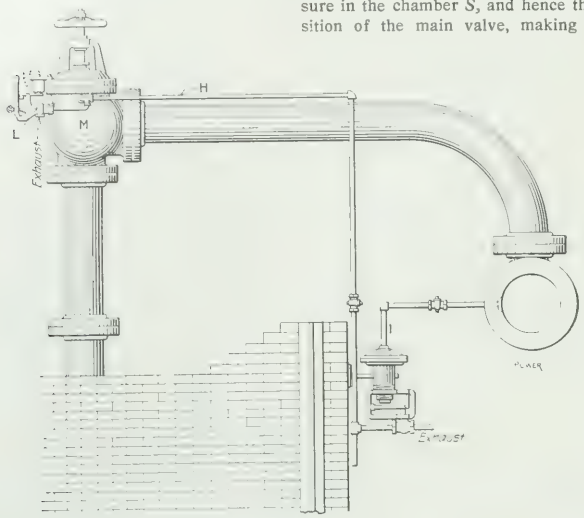


Fig. 3. Arrangement of Pilot Valves and Piping

nal conditions. Steam is admitted through he passage *P* to the chamber *Q* and hrough the port *R* to the chamber *S*.

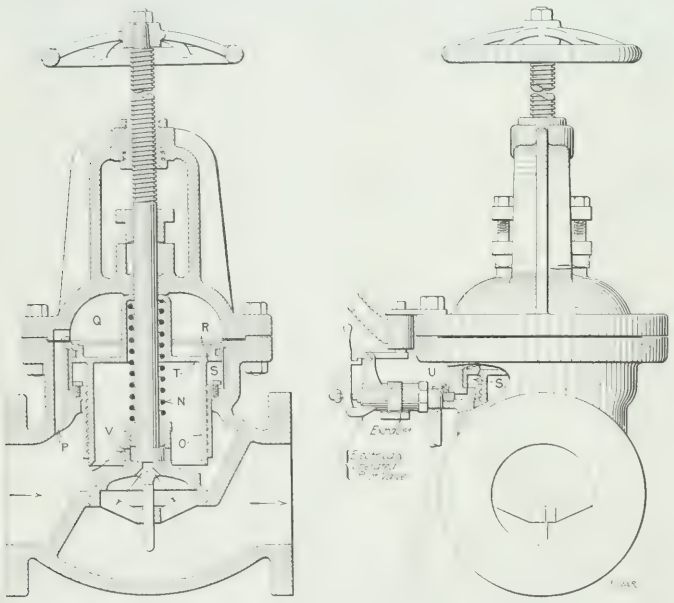


Fig. 4. Throttle Valve and Automatic Engine Stop

Thus the pressure above and below the head *T* is the same.

If the pressure in *S* is suddenly reduced, the total pressure acting downward on *T* becomes greater than that acting up, and the valve is closed.

Electrically or hand-operated pilot valves connected at *U* control the pressure in the chamber *S*, and hence the position of the main valve, making it an engine stop which may be operated from as many points as desired.

When the arrangement shown in Fig. 5 is attached to the engine, the valve becomes an automatic stop operated by any overspeeding of the engine.

The small ports *V* in the main valve of Fig. 4 are for the purpose of allowing a small quantity of steam to go through when the valve is closed to keep the engine cylinder warm. This arrangement does away with the necessity of an external bypass.

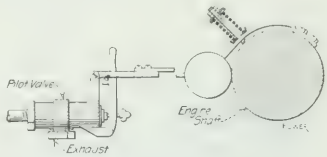


Fig. 5. Pilot Valve Operated by Centrifugal Device on Engine Shaft

These valves and a full line of standard and special cocks and valves are manufactured by the Golden-Anderson Valve Specialty Co., Pittsburg, Penn.

Cotton versus Manila Rope

By Henry D. Jackson

It is quite evident from reading a recent article on transmitting power by rope drive that the writer refers to manila rope, as he states that manila rope is mechanically far better suited for driving purposes than cotton.

While it can be stated that a cotton rope 2 in. in diameter will transmit approximately 90 hp. when operating at a speed of 7000 ft. per minute, it should be noted that such speeds are uncommon in this country and are impossible with manila rope. With this rope the speed is limited between 4000 and 5000 ft. because of the material effect which centrifugal force has upon the driving power and very high speeds have a decided wearing effect upon this type of rope.

The same general rule as to strain for manila rope holds equally true for cotton; that is, the maximum strain is 200 times the square of the diameter of the rope. With manila rope, however, the centrifugal force must be deducted in order to get the exact driving power, and when the rope velocity exceeds 5000 ft. per minute the driving power rapidly diminishes, owing to the effect of centrifugal force.

With cotton rope, this condition does not exist to any such extent. If properly made, cotton rope may wedge into the groove in the driving wheel because the cotton fibers are soft and do not cut one another, and this wedging permits a far higher speed before the effect of centrifugal force becomes serious.

With manila rope, this wedging action cannot take place. Although the manila fiber has great tensile strength, transversely it is small, and the fibers are tough and hard and will, if compressed, seriously injure one another. For this reason the grooves must be so designed

as to avoid any material wedging and as this wedging cannot be used, centrifugal force will naturally affect the rope to a considerable extent.

The pulley diameters which can be used with manila rope range from 36 to 50 times the diameter of the rope. With a smaller pulley, particularly at the higher speeds, the bending action of the rope around the pulley seriously injures the fibers. With cotton rope, however, the pulley diameters may be reduced to 30 times that of the rope without any difficulty, and under certain conditions to even less.

Rolling is particularly recommended for manila rope as this tends to increase its life by maintaining it in its original cylindrical form and preventing it from assuming a wedge shape, which will ruin it in a short time. Rolling is to be deprecated on cotton rope, however, but the wedge shape is desired because it increases the tendency of a rope to wedge into place, thus increasing the driving capacity.

The number of strands used with manila rope varies from three to six, depending upon the size of the rope and the condition of the drive. The four- and six-strand ropes are more expensive in first cost and also in working, but owing to the fact that the ropes do not meet in the center, a core is required which takes up room and actually does nothing in the driving; it is also a nuisance when splicing becomes necessary.

For cotton rope three strands are sufficient; the rope is then easier to make and easier to splice, both of which items are of considerable importance.

There seems to be a lack of interest in this country regarding cotton rope. Rope manufacturers here claim that manila rope is superior to cotton, and judging from cotton ropes that have been put on the market, this is true; this, however, may be due solely to lack of experience in the making of cotton rope.

It is hard to believe that cotton rope is not equal to manila, particularly when one knows that the former is the only satisfactory medium of transmitting power to the spinning-mule motions, not only in this country but abroad. Leather belting, manila rope, etc., have failed; cotton rope has been a success from the start. The average life of manila rope, according to the manufacturers, is from 6 to 12 years, but many rope drives cut out in a much shorter time.

Another claim is that manila rope will transmit more power at the same speed. That may be true of the cotton rope manufactured in this country, but the experience of the English, French and German manufacturers proves the contrary. Many drives abroad have been running from 16 to 20 years without failure, and there are well authenticated instances of drives that have been running from 23 to 30 years, and are still running; these, however, are all of the English or single-warp system.

As for the transmitting power of cotton rope, the writer will cite two instances where this rope replaced the manila rope. In the first case, six 2-in. cotton ropes replaced eight 2-in. manila ropes, and did equal work and proved far more satisfactory than the original drives. In another, eight 1¾-in. ropes replaced 10 of manila, with a corresponding improvement in life and driving.

So long as it is impossible to get a satisfactory cotton rope in this country, users should not hesitate to install a manila rope drive in many places in preference to belts or electrical motor; all kinds of drives have their places, and the rope is among the best.

An Engine Room Experience

By Alonzo G. Collins

Many years ago I was in charge of an old-fashioned slide-valve engine which furnished the power for a wood-working establishment. Machinery had been added from time to time, and the engine had been speeded up to 110 revolutions per minute to handle the increased load until it kept Hans, the fireman, busy keeping up steam in the two boilers with the fuel used, which was the shavings and offal from the factory.

The engine was not built for any such speed; in fact, when I took charge, it was running at about 70 revolutions per minute and with the increased speed it had to be watched very closely to prevent going to pieces under the strain. The part giving the most trouble was the piston, which was fitted with what was then considered the last word in piston packing, namely, two cast-iron rings, one inside the other, split on diametrically opposite sides. These were set out by half-elliptical springs, adjusted by setscrews, which in turn were secured by locknuts. It was good packing for the slow-moving pistons ordinarily used at that time, but at the speed at which our engine was running, the setscrews frequently jarred loose, or the rings wore down, so as to require adjusting every week.

We were in the habit of shutting down at three o'clock on Saturday afternoons, and advantage was always taken of this opportunity, while the cylinder was hot, to do the adjusting, centering the piston carefully to the bore of the cylinder and setting the locknuts securely; and as that part of the engine room was rather dark, I always had Hans hold a lamp and assist in other ways as might be needed. Things went on this way for about a year, and as this was our regular Saturday afternoon job, it would be inferred that Hans would have learned something in that time.

One day the management got the idea that my job was too easy, and they made the proposition that I do the firing as well as look after the engine. Upon demurring I was told that Hans was willing to attend to both, and that my time would be up the following Saturday afternoon.

Accordingly, the following Saturday afternoon, instead of making the usual adjustments on the piston, I got into my street clothes, received my money and left for home.

It happened that times were hard, and beyond an occasional job tinkering around an old engine, or a few days in a machine shop, I had nothing to do. Upon meeting my old boss on the street one day, he inquired if I was doing anything and, receiving a negative answer, said that he was going to put in a small engine to run the machinery in the shed down by the river, and take out the old wire-rope transmission, and I might have the job of installing it at the same wages I had been getting as engineer.

I agreed to this, and the next morning went to work. As my duties took me to the old engine room frequently, I had plenty of opportunity to see how the engineer-fireman was getting along, and from the racket the engine was making, I concluded he was not doing very well.

This went on until about 11 o'clock one Saturday forenoon, the foreman came to me and said, "The boss wants you to go up to the engine room and see what is the matter with that engine; this is the third time this morning we have shut down for want of steam, and he thinks there is something wrong." Upon my arrival at the engine room, Hans put on his coat and left, and a couple of young men from the factory were put to firing. We managed to hold through the forenoon; but I told the manager that he might as well send the hands home for the rest of the day, as it would take all the rest of the day to get the engine in order. This was done, but instead of getting things fixed for a start Monday morning, they had to get a new piston, and did not get started until the latter end of the week.

The six springs, six setscrews and the twelve locknuts were all in a heap in the bottom of the piston, where they had rattled around until the hexagon nuts had lost all semblance of shape and were just plain rings. A hole had been worn through the piston head and also through the follower, but fortunately it was not large enough to let the setscrews through, which was all that prevented a broken cylinder head or worse.

Hans was called in when I had the junk laid out on the floor, and was asked why he had let things get in such shape; his answer was as follows: "Why, I couldn't see in there," and he had been "seeing in there" every Saturday for about a year, and still had no idea why it was done. The result was that when they started the repaired engine again, I was the one who opened the throttle.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Oil Power Yacht "Mairi"

The accompanying engravings illustrate the salient features of the power plant of an oil-driven yacht recently built by the widely known Beardmore shipyard at Dalmuir, Scotland, for the Marquis of Graham, who, by the way, is president of the British Institution of Marine Engineers.

A perspective view of the engine is heavy oils, such as Texas or Solar. As a consequence, a heated combustion chamber *G*, Fig. 4, is provided to effect the starting of the engine. This combustion chamber is heated with a blow-lamp, a process occupying about 5 minutes. But, as in all medium-pressure oil engines, the heat of the explosion and compression when the engine is well under way is sufficient to keep the combustion chamber hot enough to make the engine self-

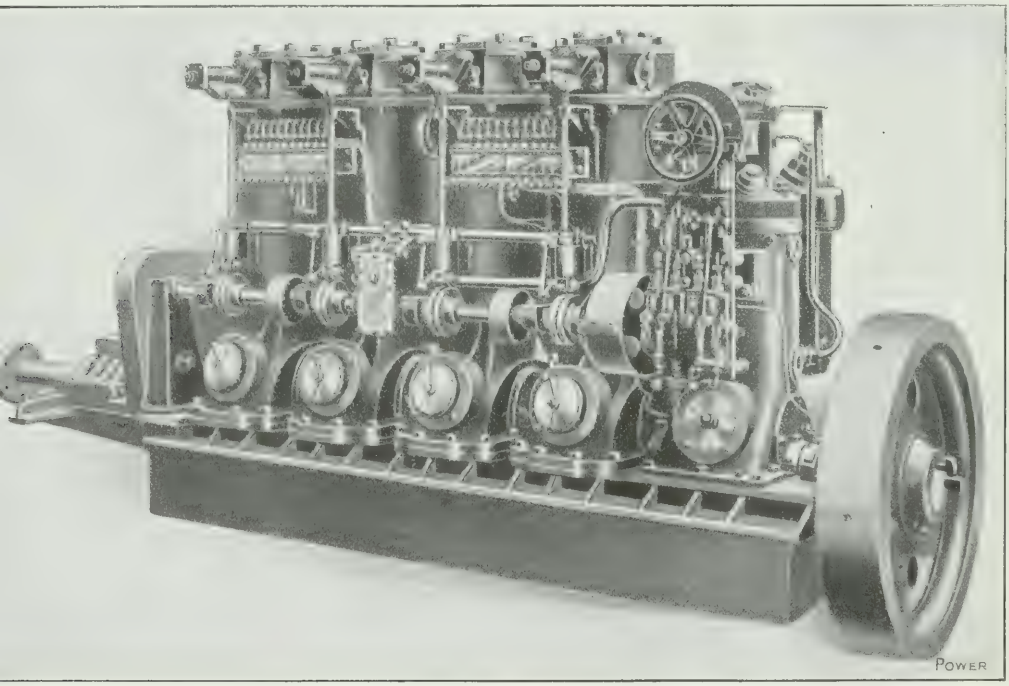


FIG. 1. MEDIUM-PRESSURE REVERSING OIL ENGINE OF THE YACHT "MAIRI"

given in Fig. 1 and an elevation and detail drawings are reproduced in Figs. 2 to 5. The location of the engine in the ship is shown in Fig. 3. The engine is the nearest approach to the Diesel type that has yet been attempted without supercharging to high compression within the cylinder. The compression is limited to 700 lb. per square inch, and the explosion pressure is never greater than 300 lb. per square inch with the lighter oils, such as kerosene, and is generally in the neighborhood of 200 lb. when using igniting. This is practically the only difference from the ordinary Diesel system of working.

Since the maximum pressure in the cylinder is so low, it is found sufficient to use air at a pressure of 400 to 450 lb. per square inch to inject the fuel, which is done in exactly the same way as in the Diesel engine. The engine works on the two-stroke cycle, the charge of air being drawn into the crank case by the up-stroke of the piston and compressed on the down-stroke. It is admitted to the cylinder when the piston uncovers the port *I*, shown in the left-hand side of the cylinder in Fig. 4.

In the engine here illustrated, there are four working cylinders 9 in. in diameter and the stroke is 13 in.; the two-stage compressor (Fig. 5) is driven by a fifth crank placed forward—to the right in Figs. 1 and 2, in which the small pumping set and thrust-block are shown on the left. The compressor crank is so placed that the primary balance of the engine is correct, and this was proved by the absence of vibration when the engine was speeded up to 400 r.p.m.; the designed speed is 350 r.p.m.

Reversing Mechanism

The starting and reversing gear and the oil and air controls are all grouped on the forward end of the engine, so that everything necessary for working the engine is at the engineer's hand. The maneuvering of the engine is done by

means of one handwheel with a pointer moving over a dial (*E* in Fig. 2). In the middle position the engine is stopped; to go ahead or astern the wheel is simply moved to the right or to the left.

There are four fuel pumps, one to each working cylinder, driven by two eccentrics, and the discharge from these is regulated by the handwheel acting on the suction valves, so that any speed from 0 to full ahead and from 0 to full astern may be obtained by the same movement that admits the fuel injection air to the inlet valves and the starting air to the working cylinders. Each fuel-oil pump is also fitted with a separate adjustment, so that any one cylinder can be given more oil independently of the handwheel control. The pump plungers have a device for hand pumping in order to force the fuel oil up to the inlet valve before starting, so that on the first revolution of the engine the oil is sure to be injected into the cylinder, and thereby the minimum amount of starting air is required. The fuel oil is also under the control of the governor, which can cut off the supply, no matter what the position of the handwheel may be.

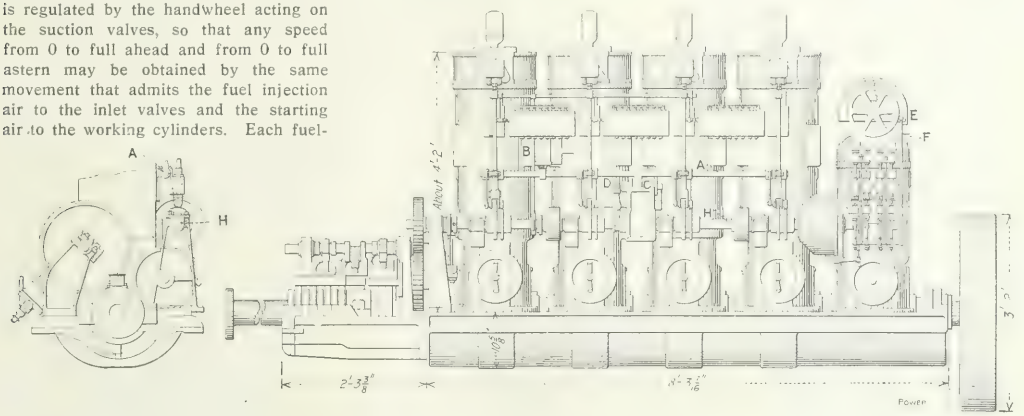
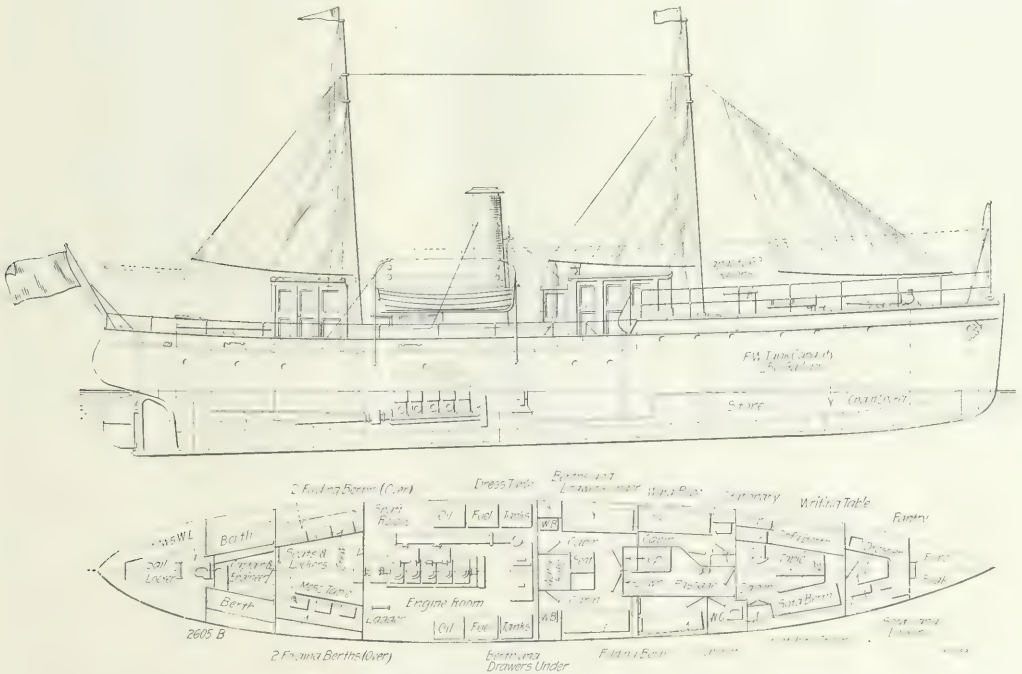


FIG. 2. END AND SIDE VIEWS OF "MAIRI" ENGINE

Two cams have been adopted for reversing the injection valve, on account of the greater flexibility obtained in manufacture; and these are operated by the camshaft *H*, Figs. 2 and 4. Above the cams, and on the end of the push rod operating the valve, are two rollers mounted eccentrically on a spindle, as shown in Figs. 2 and 4. The spindle is connected to a layshaft *A* (Figs. 2 and 4) running along the engine, and this layshaft is rocked by a small air cylinder *B*, Fig. 2, so that either one or the other roller is dropped into gear. This cylinder is shown between the two aft working cylinders. The arrangement of levers between the camshaft and layshaft is shown in Figs. 2 and 4.

The air-starting gear consists of a rotating plate with one hole in it, and this


Store
Engine Room
Oil
Fuel
Tanks
Berth
Berth
Berth
Engineer
Saloon & Lounge
Mess Tables
Dress Table
Writing Table
Pantry
Bath
Bath
Bath

passes over a faceplate containing four apertures, one for each cylinder, equally spaced. The rotating plate is driven from the camshaft by means of spiral gears and is consequently at right angles to the camshaft. To reverse, it is only necessary to turn the rotating plate through a certain angle, and this is done by sliding one of the spiral gears by means of another air cylinder. This gear is located between the two center cylinders, at *C* in Fig. 2. The air cylinder is located just above the camshafts, and slides the gearwheel on the camshaft by means of a simple lever arrangement *D*.

The air cylinders for reversing the injection valve and air-starting arrangement are fitted with pistons having piston rods of such diameter that the area on the back of the piston is twice the area

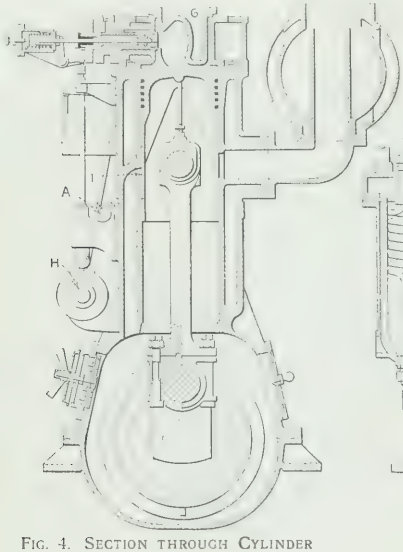


FIG. 4. SECTION THROUGH CYLINDER

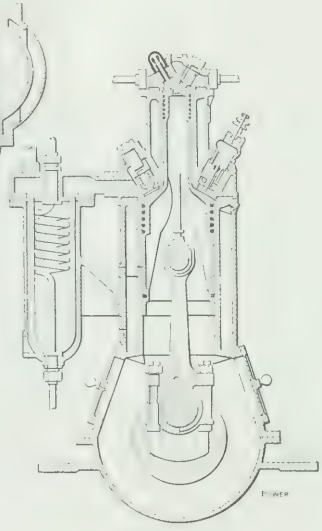


FIG. 5. COMPRESSOR

on the front. The lesser area is permanently connected to the air-storage tanks, so that the pressure pushes these pistons hard back in the cylinders. The gear is then in the ahead position. When pressure is admitted to the large area, it overcomes the constant pressure on the small area and the gear is pushed into the astern position. To bring the gear back into the ahead position, it is only necessary to open the large area to exhaust, when the constant pressure on the small area instantly asserts itself. These operations are accomplished by the handwheel *E* opening and closing two small air valves by means of cams keyed on the spindle. Two other cams are similarly used for controlling the starting and injection air, and a special one is used for acting on the suction of the fuel pumps, so as to give all the gradations from stop to full speed. These latter three cams have double raised portions on them, so that they open the valves no matter in which direction the handwheel may be turned. The cam for opening the starting air valve is mounted on a spindle which passes through the center of the handwheel, and a knob is fitted to the spindle. If this knob is pushed in, the cam is moved along with it against a spring, and the starting air is shut off.

The method of operating the gear is as follows: The handwheel is moved over, thus dropping the oil pumps into gear and turning on the injection and starting air. As soon as the engine is under way, the knob is pressed in, cutting off the starting air; it is held in by means of a little plunger operated by a spring. To stop, the handwheel is brought back to the center, and when in this position the air-starting cam springs back into gear, so that it is then able to admit starting air, no matter in which direction the handwheel be turned. The rod *F* is pulled up by means of the handwheel *E*, in order to shut off the oil. It is pushed back by a spring when the handwheel is returned to its original position.

At the after end of the engine, close to the thrust block, a small pumping set is arranged. This consists of a circulating and bilge pump and a small air compressor for keeping up the supply for maneuvering and whistle blowing. There is also provision for taking air from the main engine compressor for charging up the reservoirs. The engine is equipped with a very complete system of forced sight-feed lubrication, and the quantity to any pin bearing or cylinder is under individual control; an arrangement for flooding all the parts before starting up is also provided.

The engine has been designed especially with a view to continuous running, and all the parts are made easily accessible. To take off the cylinder cover it is only necessary to undo two small pipes and the stud nuts, and it can then be lifted away. The main bearings and crankpin bushes can also be removed in a few minutes, and all adjustments can be made while the engine is running.

Two large air tanks are installed for providing maneuvering air, and contain sufficient air for about 40 starts. In entering and leaving the dock at Liverpool recently, as many as 30 stops and starts were necessary, and these severe conditions were easily met, the engine never once refusing to reverse. It was also noticed that the engine was slightly quicker than the Diesel engine in starting, and that a drop of about 5 lb. in one air tank was sufficient to give a start.

The fuel-oil consumption is 56 pints of crude Texas oil of 0.875 specific gravity per hour, about the same as in Diesel engines of the same power (130 hp.). The indicator diagram, Fig. 6, shows the low maximum pressure obtained.

An auxiliary oil engine of 7 hp. is carried, and can be coupled direct to the dynamo, air compressor, and fire and bilge pump. The dynamo provides current for working the windlass, as well as for the electric-light installation and electric radiators. Circulating and bilge pumps are also driven off the shaft.

The motor yacht here illustrated, named "Mairi," is the largest full-powered crude-oil motor yacht so far

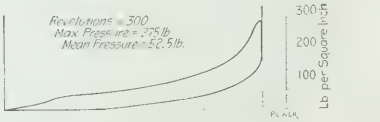


FIG. 6. A TYPICAL DIAGRAM

constructed in Great Britain. The hull is 80 ft. long between perpendiculars, 85 ft. over all, 13 ft. 6 in. beam, and 8 ft. 1 in. molded depth amidships. The "Mairi" has been designed for making extended cruises, and is quite capable of going to Norway or the Mediterranean without involving undue endurance on the part of her crew.

On trial the yacht obtained a speed of 10.3 knots as a mean of six consecutive runs on the measured mile, and accomplished a very satisfactory 24-hour nonstop run at full speed in the Firth of Clyde, the engines developing 130 brake horsepower when running at normal speed. At this speed the fuel-oil tanks have sufficient capacity to give a radius of 1000 sea miles.

We are indebted for the foregoing particulars and the accompanying illustrations to *Engineering*, of London.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

THE OPEN FLAME-ARC LAMP

1233. *Are there any other types of carbon arc lamp?*

Yes; there are two other types, closely related to each other and both known as "flame-arc" lamps.

1234. *What is the difference between them?*

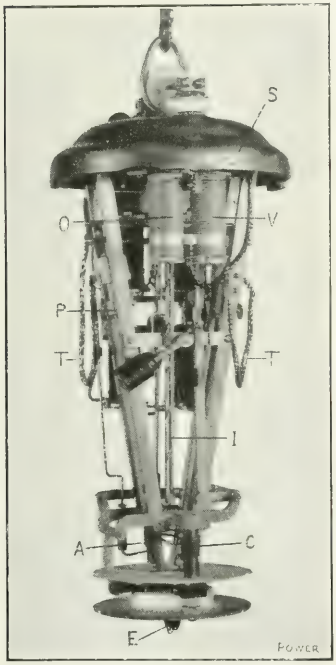


FIG. 408. OPEN FLAME-ARC LAMP

One is of the open type and the other inclosed; this apparently small difference, however, causes a great difference in the arrangement of the carbons and the design of the mechanism which "feeds" the carbons as they are consumed. In the open type both carbons project downward, with their active ends close together and their mount ends separated, and both are fed downward. The carbons of the inclosed type are arranged end to end, exactly as in the ordinary arc lamp.

1235. *Illustrate and describe an open flame-arc lamp.*

Figs. 408, 409 and 410 show interior views taken at different points around such a lamp. Upon close inspection of Fig. 408 it will be evident that the carbons *A* and *C* both extend downward at opposite angles with the vertical center line of the lamp, the lower ends nearly touching at *E* when the lamp is "dead." The arc is found between the facing portions of the carbon tips and to prevent it from creeping up the sides of the carbon rods a magnetic field is provided by magnet poles located at *M* and *N*, Fig. 409.

1236. *How do the magnet poles prevent the arc from creeping up the carbons?*

The field produced between the poles "blows" the electric arc downward by magnetic repulsion. This causes the arc to curve downward and expand into a sort of flame, as represented in Fig. 411. It is from this that the lamp gets its name.

1237. *What is the function of the part shown at* D, *Fig.* 410*?*

This is a chamber of highly refractory material which surrounds the ends of

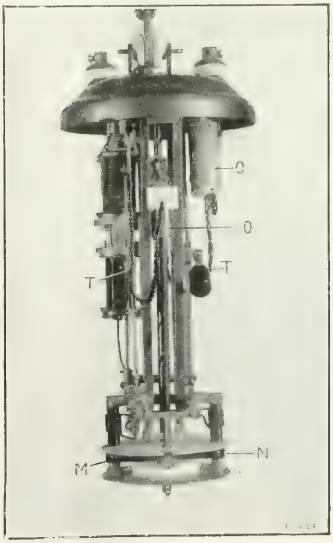


FIG. 409. SIDE VIEW OF FIG. 408

the carbons and shields them from "washing" of the air currents within the globe. This part of the lamp is called the "economizer" and is necessary on account of the rapidity with which the carbons are consumed.

1238. *What is the type of feeding mechanism used?*

It is of the differential solenoid type and is shunt starting; that is, when there is no current through the lamp the carbons are apart. When the current is switched on, the shunt coils *F* and *G*, Fig. 410, are first actuated, pulling the

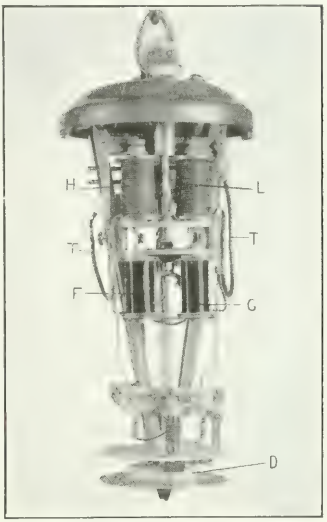


FIG. 410. OPPOSITE VIEW FROM FIG. 408

carbons into contact and thereby establishing a circuit through the series coils *H* and *L* and the carbons. The series windings then pull the carbons upward, separating the ends and forming an arc, which is thereafter differentially regulated by the shunt and series coils as described in the previous section of the Catechism.

As the carbons burn shorter they are fed downward by means of the central spiral rod *I* down which travels a crossarm that carries the carbon holders *P* and *Q*. The rod *I* is nickeled to insure smooth traveling for the crossarm and extends up into the casting *S* where a speed-reducing escapement is located.

1239. *What are the objects at* T, *which resemble strings of beads?*

These are the leads connecting the carbon holders to the circuit; they are insulated by glass beads which are threaded on them.

1240. *What is the purpose of the coils* O *and* V, *Fig.* 408*?*

They are voltage-reducing and steadying resistances used in series with the lamp when one lamp is connected to a 110-volt direct-current circuit. By using a reactance in place of the resistance, the lamp can be operated singly on 110-volt alternating-current circuits.

1241. *What kind of carbons are used in this lamp?*

Cored carbons containing metallic salts

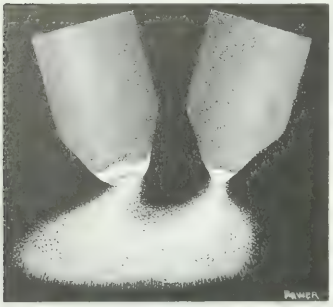


FIG. 411. A "FLAME" ARC

and a metallic strip running throughout the length.

1242. *How long will the carbons burn?*

One set will burn about 17 hours with a current of 12 amperes.

1243. *What advantages have the flame-arc lamp over the ordinary arc lamp?*

It is much more efficient and the light is much more powerful than can be obtained from the ordinary carbons.

An Opportunity for a Real Central Station Man

BY E. M. GRAHAM

While trying to work up interest in a lighting plant for a small town I was frequently met with questions and uncomplimentary comments relating to a plant in a neighboring town; it did not pay; the service was worse than none at all, and so on. Not having been to the town mentioned I was unable to discuss the plant intelligently, but a little later an opportunity was offered to go over there and investigate, which I gladly accepted.

The town was small, the population being less than 1000 people, but they were trying to make the plant pay a manager $100 a month, a bookkeeper $25 a month and two engineers $65 a month each. The plant was located on a stream about a mile from the railroad and used water-power eight months of the year, but it so happened that the four months when steam had to be used were the months when the lighting load was the heaviest. Power was being furnished for a flour mill about half a mile distant and the engine was intended to run the mill and light the town at the same time, but it would not do it. It was rated at 100 hp. and was of the high-speed flat-valve type. The engineer in charge said the engine would not run right with the steam pressure above 80 lb. When the lighting load came on it was necessary to shut the mill down, although the lights did not require over 40 hp. at the peak and about 15 hp. for two-thirds of the night.

Thirty-two candlepower carbon-filament lamps are used on the streets and permitted to burn continuously. A system of flat rates is in use which would require a person lighting a seven-room house to pay about $4.50 per month regardless of the current consumed, with the natural result that many people refuse to use the service.

There is no means of weighing the coal, hence it is impossible to tell what proportion of the fuel should be charged to running the mill. The engineer thought that the engine valve leaked but had never had an indicator on the engine to determine its condition.

The owners denied losing money on the lighting business; if they are not losing money they certainly could make a handsome profit if they would install an engine of a size to handle the lighting load economically, provide means for shutting off the street lamps when not needed, adopt rates that would attract business rather than drive it away and cut down the expenditure for salaries to a point appropriate to the size of the plant. If the manager so manages things that he has no time to keep the books a different management would seem to be advisable.

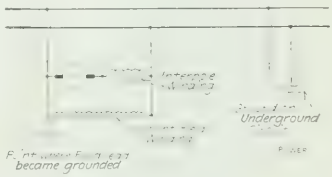
LETTERS

Peculiar Cause of Racing

Some time ago I had occasion to clear up what proved to be a comparatively simple trouble case, but it was extremely puzzling at the time because of the manner in which it made itself manifest. The apparatus involved was a 5-hp. 220-volt shunt-wound interpole motor, installed with a Cutler-Hammer drum-type controller which varied resistances in both the armature and the field circuit. The resistors were contained in a separate case.

After this equipment had been installed and connected up it was found that the motor speeded up far beyond the maximum rated speed of 1600 r.p.m. and sparked violently with the controller set so as to put about half of the external resistance in the field circuit. My first conclusion was that the man who made the connections between the controller and the resistor case had got some of the leads between the several controller contact buttons and the various field resistor taps confused. On second thought, however, I realized that this would only cause the motor to attain its maximum rated speed, assuming that the middle contact button was connected to the last field resistor tap. The indications pointed to a complete loss of field excitation.

In order to eliminate all questions of fault in the controller, I disconnected the two field terminals of the motor and connected them to a small water rheostat. On starting up the motor it operated precisely as before, running away after reaching a certain speed. On applying a piece of iron to the undersides of the pole tips, my theory as to a complete loss of field was verified. Upon removing the journal bracket at the pulley end of the motor to look for what I thought was an intermittent loose connection between two of the field-magnet coils, it was found that in rotating the end bracket for inverted hanging of the motor, the man doing the work had managed to squeeze one of the field leads between a coil and a part of the end bracket, causing a partial ground, the resistance of which, when the vibration and stresses on the bracket reached a certain value (depending on the speed), became low enough to shunt out the



GROUND IN FIELD LEAD

higher resistance of the field winding, but not sufficiently low to cause a dead short-circuit of the motor. The motor was supplied from a two-wire circuit one side of which was grounded by a fault on an underground cable connected to the same line and the field winding was shunted out by two grounds, as shown by the accompanying diagram.

After insulating the break in the field lead, reassembling and connecting up, the motor operated all right.

CHARLES E. MEAD.

Jermyn, Penn.

Rewinding Induction Motors

Following the advice in R. H. Fenkhausen's article in the Jan. 30 issue on "Rewinding an Induction Motor Stator," as to the use of oiled linen or cambric in the slots next to the coils, would be likely to cause an amateur winder a great deal of trouble.

I would suggest that a thinner amount of first insulation be put on the coils in order that the correct thickness of leatheroid or fish paper can be used for the cell proper. If the voltage would permit, it would probably be better to use two thicknesses of thin leatheroid with the oiled linen between, rather than put the line next to the coil.

L. EARLE BROWNE.

Roundup, Mont.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Siphoning and Boiling Over

By Walter C. Edge

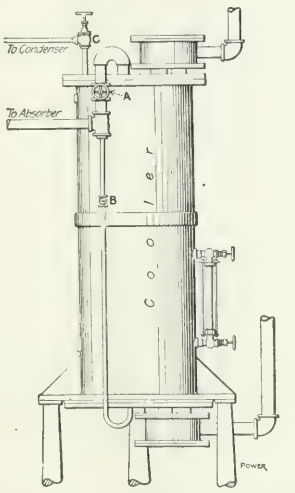
When a steam boiler is worked too hard, it will foam, and sometimes considerable water will go over with the steam. It is just so with the generator of an absorption system. If it is pushed too hard it will boil over, and considerable moisture will go over with the gas into the condenser. This eventually reaches the cooler or cooling coils, where it stays until taken out by purging. This rarely ever happens with a horizontal generator or still, but it is not uncommon with the vertical type.

In the writer's opinion boiling over occurs in the majority of cases when the condenser is empty, all of the anhydrous ammonia having been sent throughout the system. This gives the cooling water in the condenser very little to do, and the velocity of the incoming gas is greatly increased, thus exerting the same pulling or siphoning effect on the generator as a heavy overload would on a steam boiler.

If the machine is worked hard, it is advisable to carry more anhydrous ammonia in the system than is the usual custom so as to be able to hold considerable liquid ammonia in the condenser at these times. Of course, a little moisture will go over with the gas at all times, but this should go no further than the rectifying tank. The water in the tank should be kept at 110 to 120 deg., and if kept at this temperature the moisture will be trapped and sent back to the analyzer. Should the water become too hot, the moisture will go through with the gas and lie in the cooler or cooling coils until taken out by purging. Again, should the water be too cold, the rectifier will trap not only the moisture but considerable gas; and in a short time the aqua solution will become so strong that it will not do its work properly. This can be explained more clearly by describing the actual operation as follows:

The weak liquor leaves the generator very hot, its strength being about 18 per cent. It is cooled considerably by passing through the exchanger, and in some cases in the weak-liquor cooler. Arriving at the absorber, it is sprayed from the top and absorbs about 10 per cent. of gas, making its strength 28 per cent. It falls to the bottom of the absorber and is pumped back through the exchanger, equalizing temperatures with the outgoing weak liquor. After passing through the exchanger, it goes to the analyzer, where it falls over hot plates, as in an open heater, to the generator or still below. When it reaches the analyzer it is very hot, and gives off very nearly all the gas it has absorbed, coming back to a strength of 18 per cent. when it reaches the generator.

If the rectifying tank is too cold and sends back much of the gas just liberated, it is easy to see that the strength of the weak liquor in the generator is going to rise, and for every 1 per cent. of strength



The Cooler of an Absorption Plant

added to the weak liquor in the generator, 1 per cent. less gas will be absorbed from the cooler or cooling coils when it reaches the absorber. This will show on the gages, the pressure going up on the generator absorber and cooler. It is at this time that the machine will siphon, or, in other words, weak liquor will go over to the cooler if care is not exercised. If the expansion valve is shut off the pressure in the cooler will be greatly reduced and it is liable to siphon from the absorber. The writer knows of one particular case where this difficulty was overcome by putting a check valve between the cooler and the absorber. It can be prevented, however, by keeping plenty of cooling water on the absorber, and not shutting the expansion valve entirely.

Another valve of great importance is the one in the steam line to the heating coil in the generator. The setting of this valve should be studied carefully as it is important to know the proper pressure to carry on the steam coil for best results. If the pressure is too low the weak liquor becomes strong, giving the same trouble just gone over. If the pressure is too high, the head pressure on the generator becomes excessive, and there is a great chance of its boiling over.

It is, of course, best to keep the cooler as free from moisture as possible, and the only way to get it out is to purge the cooler. This may be done in three ways: The usual one is to close the gas valve *A* in the illustration and open the purge valve *B*. This way of purging necessitates stopping the cooling process. A method possibly new to some engineers is to have both of these valves open at the same time, allowing the cooler to do work while being purged. The disadvantage in this method is that it takes a long while to do it, and meanwhile very little useful work is done. If it is necessary to purge the machine in a hurry, the small valve *C* connecting the condenser to the cooler may be opened, thus putting the condenser pressure on the cooler and forcing out the moisture. It is not advisable to purge in this way as it throws the cooler back too much.

It is a good thing to open the weak-liquor valve a little more than usual when purging the cooler, so as to send enough weak liquor over to absorb all the gas, as trouble is sometimes caused by the ammonia pump becoming gas-bound. It is a very good idea to have a valve on both the suction and discharge line to the pump. Should the pump get gas-bound it can be relieved by opening one of these valves and discharging the gas into a bucket of water.

LETTERS

Piston Rod Packing

Several years ago I had the same trouble with ammonia pump piston-rod packing as described by H. G. Gibson in the Feb. 20 issue. The rods had been badly scored by a former engineer, who used hard hemp packing and allowed it to get dry and burnt. I tried several remedies, but the one giving the best results was to use alternately a ring of soft flax and a ring of composition packing. The combination kept the rods tight and well lubricated. After putting in

new rods, I tried a wedge ammonia packing, but obtained the best results by using a header ring of the composition packing at each end of the gland with the wedge packing in the center.

L. M. JOHNSON.

Glenfield, Penn.

I took charge of an absorption plant and soon had trouble with the piston-rod packing. It had become misplaced and what liquor passed the spool was forced out. After cleaning the stuffing-box I inserted rings of packing: a solid one first, then diagonally split rings and a solid one again next to the spool. This was repeated on the outer end of the spool, making four solid rings and all of the rest split rings. A little graphite on the rod will prevent any trouble.

My machine runs 24 hr. a day, four months in the year. I have been here for three years and have only packed the pump three times. The present packing has been in for over a year and is still all right. The pump is a 7 and 2½ by 10-in. I do not draw the packing up too tight to begin with, and after one day's run I loosen it up a little.

ARDAN MITCHELL.

Brooklyn, N. Y.

Troubles in Refrigerating Plant

On a 50-ton ice machine the crankpin suddenly became hot, although the oil cup was feeding regularly. The engineer in charge was not a believer in sand for hot boxes before he knew the cause of the heating. Another machine was started and the machine giving trouble was stopped so that the head of the ammonia compressor could be removed. When the head had been taken off, it was found that one of the discharge valves in the casting had been forced wide open on account of a broken spring.

On another occasion I had just spoken to the fireman and everything in the boiler room seemed to be in good order. When I went back to the engine room I noticed that the engine and pumps ran slower and that my steam gage showed only 60 lb., while the fireman's gage, at which I had just looked, showed 105 lb. This was a mystery to me and I notified the chief, who at once gave the fireman orders to bank the fires and close the stop valve on each of the two boilers that were running.

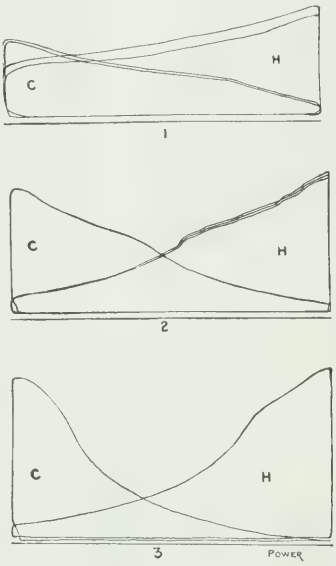
Above the stop valve on the boiler there was another valve in the main steam line. Upon taking the bonnet off this valve it was found that the stem on the disk had broken off and had fallen on its seat, partly shutting off the steam supply to the engine room and thus causing the drop in steam pressure.

WILLIAM S. KEIL.

Philadelphia, Penn.

Diagrams for Criticism

Here are three indicator diagrams, taken from the ice machine in our plant, on which I would like readers of POWER to comment. The engine, 14x14 in., has a Meyer cutoff and I was told by the makers' representative that the most economical point was where I took the first diagram. I would like to hear from readers as to adjustment for equal load on both ends of the cylinder and as to whether diagram No. 1 or No. 2 shows the most economical running conditions.



DIAGRAMS TO BE CRITICIZED

G. L. LYONS.

New York City.

What a Knock Revealed

While in conversation with the manager of a meat market, he told me that an ice machine which he had installed a short time before was giving very poor satisfaction. The company installing it had upon his request sent two men out to the plant at different times. The first advised him to put more ammonia in the system. When the next man came he took out about the same amount as had been put in. Before leaving he advised the manager to replace his compressor with a new one, it being second-hand.

The first thing I observed was a peculiar knock or pound which was noticeable on only one stroke of the piston. Next, the discharge pipe from one end of the cylinder was nearly cold while the other was quite hot. I said I believed that the discharge valve was stuck. That night he examined all the valves and found the discharge valve held from its seat by rust and other foreign matter from the pipe lines.

The compressor had been working on one end only and after cleaning the valve and valve seat the knock ceased and the compressor worked to its full capacity.

DELBERT J. MEANS.

Indiana, Penn.

Alarm for Cold Storage Room

The falling temperature of a cold-storage room might at some time result in a large loss to the company, so I have rigged up the alarm shown in the accompanying sketch. It is made as follows:

Take a glass tube 7 or 8 in. long and ⅜ in. in diameter, close the bottom end with sealing wax and through it insert the bare end of a No. 18 magnet wire. Fill the tube about three-fourths full of mercury and on top of the mercury put a float of wax in which the bare end of a magnet wire is inserted and bent as shown in the sketch.

The tube of mercury is fastened to a base with clips of metal. At the upper end of this base an adjustable lever is attached and the electrical connections are made as shown in the diagram.

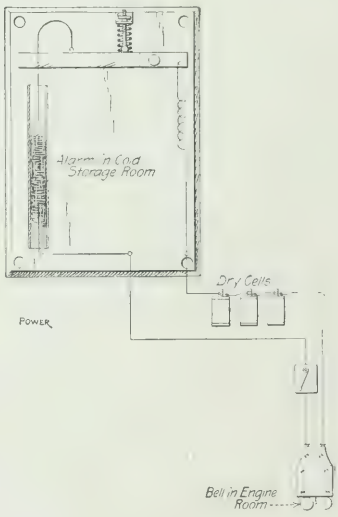


DIAGRAM OF ALARM

Should the temperature in the cold rooms fall during the day or night the mercury will contract and the float in descending will close the circuit so that the bell will ring and warn the engineer. The adjustable lever allows setting the alarm for various temperatures.

MARTIN MCGERRY.

Holley, N. Y.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 28,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Cotton Rope Drive

It has been said, and may be true, that the reason why cotton rope has not been a success in this country as a transmission material is that American manufacturers and engineers, though progressive and willing to try new things, are not sufficiently analytical and thorough in their trials. They will install a drive, and if it is a success, well and good; if it is unsatisfactory, it is discarded without attempting to discover why and to eliminate the cause. Abroad, manufacturers and engineers are progressive in a far different way. If a thing fails there, a careful, systematic study is made as to why it failed and the cause of failure is removed if possible. Sometimes a few minor changes will result in a drive which was formerly a failure becoming a decided success.

Not many years ago an American engineer installed a rope drive in a large plant. He had no experience whatever in the designing of this type of drive, and he laid out the grooves in the pulleys in accordance with his ideas. The drive lasted but a short time, and the whole output was consequently scrapped without hesitation and belts at once replaced the ropes. The entire trouble was due to the faulty design of the grooves.

This same experiment was tried much earlier abroad and the results were similar, but the rope drive was not thrown out. The engineers experimented with different forms of groove and shortly discovered the right shape for the conditions; after this was found the rest was easy. The drive was far superior to the belt and it has remained in service ever since.

It is to be noted that unless the grooves are properly shaped and adapted to the material of which the ropes are made, no rope drive will be a success and none should be installed without first carefully considering the character of the material employed and the conditions under which the drive is to be used. Correctly designed and constructed, a rope drive is a very satisfactory method of transmitting power—in many instances it is superior to belt or electric drive—and is at the present time one of the best methods of operating shafting which is a considerable distance from the driving engine.

Control of American Water Power

The report of Commissioner of Corporations Smith, on the development and control of water-power in the United States, is of interest to the public, but it particularly claims the attention of engineers.

With the development of high-tension electric transmission, hydro-electric practice has grown steadily and rapidly. Because of this there has come into existence what would soon become a complete monopoly of this important field. The report states that ten large groups of industrial interests own and control 60 per cent. of the total developed water-power in the country as well as many undeveloped power sites. As the maximum available waterpower, according to the United States Geological Survey, is between sixty-six and sixty-seven million horsepower, the question of ownership is one of grave concern, and the commissioner warns against the tendency to monopolistic control of such an immense industrial asset and recommends the encouragement of more extensive water-power development by an equitable leasing system. This is in accord with the recommendations of Pinchot, Newell, Garfield and others active in the conservation program of the Roosevelt administration.

That the federal government should retain the control of the fourteen million horsepower of water power now owned by it is not only progressive conservatism but good business management as well, and the people should receive the benefits to be derived from its use, allowing a fair profit to the enterprising

individual or corporation which develops it.

The total stationary-engine power in use in this country is approximately thirty million horsepower, and the total developed water power is about six million horsepower. The additional water-power now susceptible of economical development is estimated at nineteen million horsepower. It is further estimated that the water-power now in use effects a saving of thirty-three million tons of coal a year; when all the available water power is developed, one hundred and fifty million tons a year can be saved. The obvious importance of this will be more forcibly realized when it is recalled that coal can be used but once, while water power is inexhaustible.

From the capitalist's viewpoint, the economy of operation of the hydro-electric plant is the strongest stimulus to its development. Where the market area to be served is great and the individual power sites are small and distant one from the other, the method of tying-in several plants on a single system of transmission lines seems to be a profitable one. During low loads a few of the plants could furnish service while those idle were accumulating "pondage" for reserve purposes.

It is this facility of combination that has led to monopolistic control of water-power. The present concentration of control in the hands of a few large financial interests interrelated by directorates and banks makes inevitable the passing of a great public asset into the realm of private control unless restrictive and protective legislation is the immediate outcome of the Commissioner's report.

Boiler Explosions

In his address before the American Boiler Manufacturers Association, at its recent New Orleans convention, S. F. Jeter said broadly that "there is one explanation for all boiler explosions; namely, the boiler or some part of it is too weak to withstand the stress brought upon it. There are many causes contributing to such weakness, and a definite cause can usually be given for most explosions."

Despite this assertion from one who is in a position to know, explosions continue to be frequent and fatal. Mr. Jeter assigns faulty design and carelessness of operation as the chief causes. It would seem that both causes were avoidable; surely the latter is, and there is no logical reason why the former should not be. It is true, the manufacturer has little to say about the operation of the boiler after its acceptance by the purchaser, but the responsibility does not end there; the owner and engineer are responsible to the community for its safe operation, and neither inadequate laws nor lax enforcement of the few good ones applying to this work should be tolerated.

Those who specialize on boiler explosions seem to be agreed that their causes are avoidable. If this is so, what action will follow the recent carnival of death-dealing explosions? To say that they were avoidable is equivalent to charging gross homicidal negligence in the light of expert opinion. The public and those engaged in engineering practice therefore are privileged to demand the enactment and enforcement of protective legal measures to determine the competency of the operating force to perform their work, and a through examination of the engineers and firemen will indicate their fitness to safely operate the equipment.

The doctrine of the "fellow servant" and "assumed risk" in its relation to boiler explosions will not long be accepted by people of intelligence if ignorance and negligence are the cause of so many explosions.

That poor feed water is frequently the initial source of such trouble is generally recognized, and its analysis and corrective treatment before its use, or perhaps its frequent removal from the boiler, should be made compulsory by law. To depend upon individual "common sense" is poor policy, as the sense of duty is often obscured by the present high-tension industrial conditions.

It is gratifying to know that the American Boiler Manufacturers Association—to whom belongs credit for the existence of the Massachusetts and Ohio rules—is making an effort the chief object of which is to minimize explosions by the adoption of uniform boiler specifications.

Its committee on boiler specifications has indorsed the Massachusetts rules and recommends the amendment of several paragraphs, substituting improvements. Among others, it is recommended that the allowable pressure on an all cast-iron boiler be reduced from twenty-five to fifteen pounds per square inch. The committee objects to basing the factor of safety on the age of the boiler, contending that it should be determined by its physical condition. This contention should receive the approval of all acquainted with everyday boiler practice.

Many other equally important amendments are proposed which it is to be hoped will be adopted. The provoking feature of it all is the indifferent attitude displayed by those who should aid the association in its commendable work.

American progress seems to be so rapid that little attention is paid to the evils incurred by it. Would it not be better to proceed more slowly and correct the evils that really impede progress than to seek consolation in the barbaric plea that such fatalities are inevitable accompaniments of an advanced civilization?

"And the coroner laid the blame on the dead engineer." For most accidents this expression seems to permanently fix the blame and the incident is closed. There are times when this verdict is a true one, but are there not others where an investigation of actual conditions by some interested engineer would free his dead brother from the stigma of gross carelessness and criminal neglect? It is a long time since the daily press has given utterance to any defensive theory from a practical operating engineer. Why?

"We occasionally get together in our power plant and discuss features of practical operation," writes a chief engineer. This is a most efficient way to get that "teamwork" which is so necessary to successful operation. The men better understand their chief, and sometimes even the chief learns something.

Pittsburg has a plan to abate its smokiness by utilizing the 100,000 hp. which can be developed by its near-by rivers and streams. If this can be accomplished, the city will be entitled to spell abatement with a capital A.

A power superintendent advocates placing the chief engineer's office in the boiler room. He believes the engineer should be "the man on the spot" if he would prevent a high heat loss and uneconomical combustion.

Boiler Explosion at Greentown, Penn.

By Carl H. Beach

Due to corrosion of the stays, an old single-riveted lap-seam boiler exploded, killing four and seriously injuring a fifth man. The building was demolished and the boiler hurled into a creek two hundred feet distant.

Shortly before 7 o'clock on the morning of Friday, Mar. 7, the boiler in the T. H. Gilpin Stick Factory, of Greentown, Penn., exploded, killing four men and injuring one other, besides demolishing the house in which it stood.

The main factory building is a two-story frame structure, approximately 80 x150 ft., with the engine and boiler rooms in a wing at one side, as indicated in Fig. 1. The boiler was of the return-tubular type, and the failure occurred in the front tube-sheet, thus driving the boiler through the back of the building up along the bank of the millrace to a point about 100 ft. from its original position, where it struck a tree at a point about 8 or 9 ft. above the ground. The tree doubled up like a jackknife and was carried bodily with the boiler a distance of some 30 ft. or more. At the point where the boiler apparently struck, the tree was about 14 in. in diameter, and at the surface of the ground where the tree also broke off, it was some 18 or 20 in. in diameter. Fig. 4 shows the tree in the position in which it was left by the boiler, the stump from which the tree was removed being shown in the lower right-hand corner.

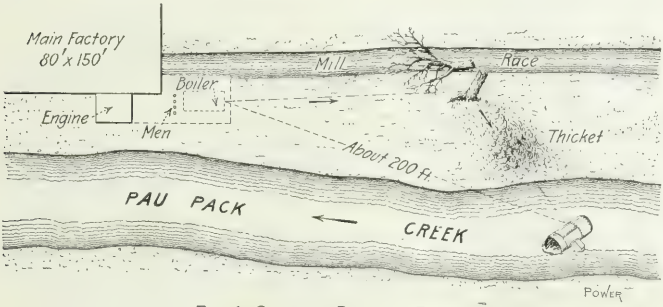
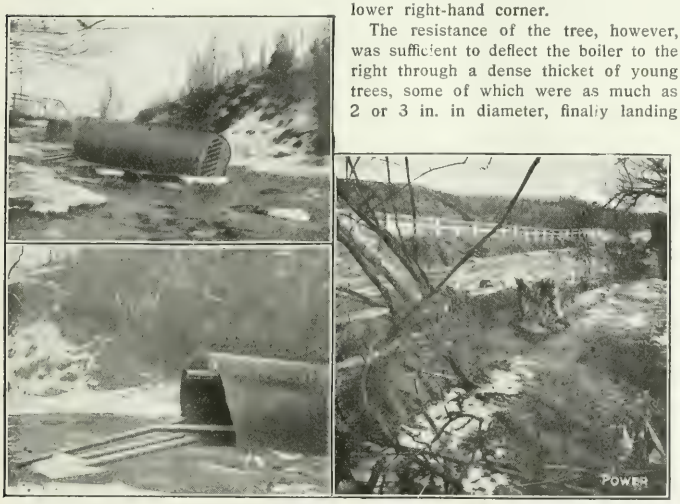


FIG. 1. SHOWING PATH OF BOILER

The resistance of the tree, however, was sufficient to deflect the boiler to the right through a dense thicket of young trees, some of which were as much as 2 or 3 in. in diameter, finally landing in Pau Pack Creek in the position shown in Fig. 2. The impact of the tree also apparently caused the boiler to turn end for end, so that the end in which the failure occurred and which originally faced the engine room was found to be pointing upstream, or in exactly the opposite direction.



FIGS. 2, 3 AND 4. SHOWING REMAINS OF BOILER AND THE TREE WHICH WAS UPROOTED BY IT.

The four men killed were sitting in front of the boiler, and when the failure occurred they were blown bodily through the roof of the boiler house. Three of them were so completely dismembered that a search of some two hours or more was required before sufficient remains were obtained to identify them. The fourth man was mortally injured and died shortly after.

A boiler explosion seems incomplete unless someone miraculously escapes, and this accident was not an exception. There was an entryway between the boiler room and the engine room, the walls of which were of light boards, and, although the impact of the explosion entirely demolished the walls on two sides of this room, the fireman who was in the room was only slightly injured. The failure of the tube-sheet also blew the fire from under the boiler onto a large pile of shavings and scrap; yet the shavings were not ignited, seeming to indicate that a large quantity of water must have promptly extinguished the fire.

It is understood that the boiler had been purchased about 28 years ago and was at that time second-hand. It had single-riveted lap joints on both the girth and longitudinal seams, and the rear head was supported in the manner shown in Fig. 5. The failure occurred not through the riveted joint, but through the solid plate at *a*, the appearance of the fracture being more that of a piece of wood that is pulled apart than of a piece of metal; in other words, the fracture appeared very much splintered, and in some cases even honeycombed. About two-thirds of the tube-sheet was carried away.

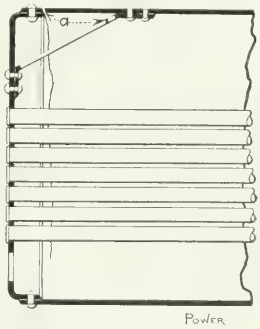


FIG. 5. INDICATING WHERE SHELL TORE

The portion of the tube-sheet above the line of tubes was stayed by wrought-iron diagonal stays, and all of these broke

near the shell, the body of the stays being carried away with the tube-sheet. The top row of tubes was also carried away with the tube-sheet, having pulled out of the front head.

The shell was ¼ or $\frac{7}{16}$ in. thick, the tube-sheet being about $\frac{3}{8}$ in. There were 40 tubes 4 in. in diameter. In no place was it possible to ascertain the diameter of the rivets, owing to the amount of corrosion. No trace of the safety valve was found and there appears to be some contradiction as to the exact steam pressure carried at the time of the explosion, although it is believed to have been about 80 lb. per square inch.

The inside of the boiler was clean, but the portion of the break that was exposed most directly to the fire was inaccessible, as it lay in the water and could not be reached easily.

The failure was undoubtedly due to the stub ends of the stays being badly corroded. The stays on the front head were also in bad condition, although they had not broken.

San Antonio Locomotive Boiler Explosion

Passenger engine No. 704, of the Southern Pacific R.R., exploded while standing in the yard at the railroad stop at San Antonio, Tex., at 9:30 Monday morning, Mar. 18. Twenty-eight employees were killed and more than 40 persons were injured. Part of the roundhouse collapsed, several small buildings were demolished, and the engines in the roundhouse were badly damaged. It is

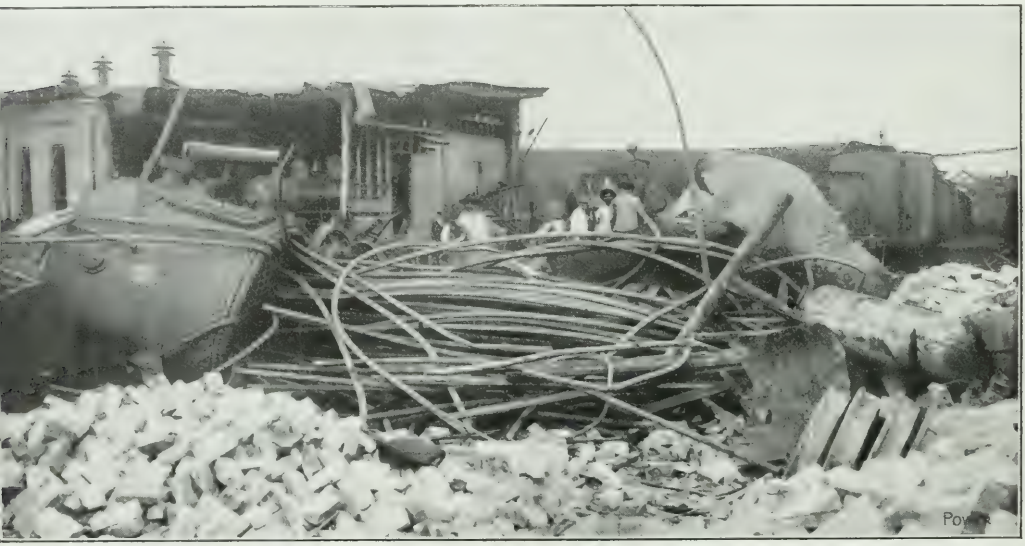


FIG. 1. ALL THAT WAS LEFT OF THE LOCOMOTIVE BOILER AFTER THE EXPLOSION

FIG. 2. VIEW OF LOCOMOTIVE DRIVING TRUCK AND BOILER REMAINS

estimated that the monetary loss will reach the sum of $200,000.

The probable cause of the explosion was excessive steam pressure. This belief is substantiated by the testimony of employees who stated at the Interstate Commerce Commission investigation that a workman had screwed down the safety valve just previous to the explosion and that the oil burners had been extinguished and then relighted shortly before the accident. All theories regarding dynamite and other explosive forces, which were at first given some credence, have been dropped by the investigating board.

In Fig. 1 are shown the wrecked engine and roundhouse. All that is left of the boiler shell is the crumpled and torn sheets, shown beyond the tube. The only part of the boiler which remains is the extension front, shown in the foreground, and the mass of tubes, some of which are still intact in the front tubesheet.

Fig. 2 shows the engine frame after the wreckage had been cleared away from around it, and gives a view of the boiler ready for the government inspector. The rear driving wheel was blown clear of the shafting, but was prevented from further flight by the side-rod connection.

A closer view of the wrecked boiler, with the running gear of the engine in the center and the roundhouse at the right, is shown in Fig. 3. The force of

FIG. 3. NEAR VIEW OF BOILER, SHOWING THE TORN BOILER PLATES

FIG. 4. VIEWS SHOWING VARIOUS PARTS OF THE WRECKED LOCOMOTIVE

e explosion tore the steel boiler plates o shreds, which from the condition of e riveted joints which are uninjured, dicates that the internal pressure must ve been excessive.

The group of photographs shown in g. 4 illustrate several parts of the exoded locomotive. A near view of the n boiler sheet and a portion of the ebox are shown; the position of the iving truck, one wheel of which is ll upon the rail, gives an accurate idea to the extent of the damage to the lonotive. It would appear from the two maining photographs that the explon was more severe at the firebox end the boiler, as the front end was card only a short distance, while the ebox end was thrown almost at right gles to the original position of the enne. That the boiler tubes and front tension were not thrown a greater disnce is doubtless due to the giving

THE REMAINS OF BOILER MINUS BOTH HEADS

ay of the boiler shell in its entirety practically the same moment.

The photographs indicate that the itial rupture occurred in the firebox d was probably due to the failure of e staybolts which were in many inances broken in two in the center. This doubtless the most disastrous locomove explosion that has ever occurred.

National Gas Engine Show

The National Gas Engine Association ll hold its first national show at Milaukee, Wis., on June 17 to 22, in the uditorium, where 100 exhibition spaces ave been laid out. The convention of e association will be held at the same nc.

Boiler Explosion at Salisbury, Md.

BY F. A. GRIER, JR.

A very disastrous boiler explosion occurred on Mar. 26, at 2 p.m., seven miles northwest of Salisbury, Md., killing six persons and injuring three others. The boiler was a return-tubular with extension front; the kind commonly used in country sawmills, such as the one in which it was used at the time of the explosion. The mill was owned and operated by Hermus Hearn, who was killed; 10 men were working in the mill.

The boiler was 44 in. in diameter and 14 ft. long, with 46 three-inch tubes; the shell was originally $\frac{5}{16}$ in. thick, the heads $\frac{3}{8}$ in. thick. The boiler was purchased second-hand five years ago and had probably never been tested since it was first built, as few of the country sawmill owners ever go to that trouble, and there is no law compelling boiler inspection in Maryland outside of the city of Baltimore.

The safety valve was of the old style ball-and-lever type and in addition to the regular safety weight there was a cast-iron cogwheel or rack pinion wired to the lever. The boiler had been standing idle all winter until a few days before the explosion, which occurred just as the engineer opened the throttle valve of the engine. The force of the explosion landed the shell 80 yd. away, tearing both heads out and landing them 20 yd. beyond the shell. Only nine of the tubes remained with the heads; the others were blown in all directions, some of them as far away as 200 yd.

The Diesel Engine

In a paper read before the British Institution of Mechanical Engineers on Mar. 15, Dr. Rudolph Diesel reviewed the history of his now famous engine and pointed out some industrial advantages obtainable by its use, especially in Great Britain. Foremost amongst these, naturally, he placed the conservation of the country's coal supply which would result from displacing steam engines with Diesel engines using tar oils as fuel. He also suggested the possibility of using vegetable oils for engine fuel and cited a test made with peanut oil a few months ago, in which the consumption was 0.53 lb. per brake horsepower-hour; the heat value of the oil was 15,500 B.t.u. per pound and it contained 11.8 per cent. of hydrogen.

In referring to the advantages of the oil engine for service in the colonies, Dr. Diesel expressed the opinion that Great Britain should emulate the progressive example set in the Congo, where a pipe line 250 miles long is under construction for the transfer of crude petroleum.

In an appendix Dr. Diesel presented a general list of oils suitable for consumption in his engines. Those which can be always utilized are mineral oils free from benzine; lignite-tar oils, and fat oils from vegetable or animal sources, such as castor oil, fish oil, peanut oil, etc. With the aid of special apparatus, it is practicable also to use pit coal-tar oil and tar from vertical water-gas and oil-gas ovens. Tars from horizontal and inclined retorts cannot be used in the Diesel engine as yet.

In another appendix the author gave a condensed summary of the vessels thus far equipped with Diesel engines. This list includes 20 oil tank vessels, one of 15,000 tons; 37 tugs, of which 22 are Russian; 8 sailing vessels; about 40 merchant vessels, one of which is of 9000 tons displacement; 14 fishing boats; about 115 submarines, ranging up to 5000 hp.; about 25 gunboats; 20 small naval boats, and 16 miscellaneous boats, mostly yachts.

The "Florida" Is the Fastest Battleship

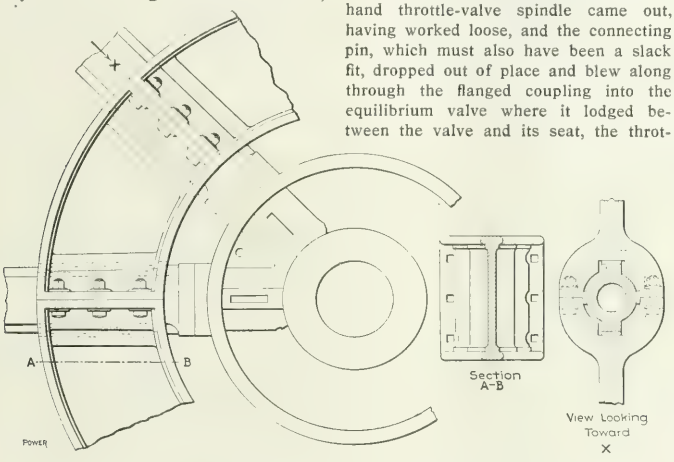
In its test on Mar. 23 in a rough sea and brisk wind off the Maine coast, the government-built battleship "Florida," by attaining a speed of 22.54 knots, set a world's record. The British dreadnaught "Vanguard" heretofore held this record with a speed of 22.50 knots. The "Florida" was built at the New York Navy Yard under the supervision of Naval Constructor William J. Baxter. Her normal displacement is 21,825 tons, and she is manned by about 900 officers and men.

Explosion of a Beam Engine Flywheel

By John S. Leese

The flywheel of a beam engine in a mill at Lancashire, Eng., burst some months ago under the following circumstances: The engine, which was bought and installed in 1845, was a double-acting condensing compound throttle-governed unit of about 200 hp. and ran at 40 r.p.m. In the course of its life the engine had naturally been improved and strengthened as the load increased, and the flywheel was strengthened in 1880 by the addition of a loose boss fixed onto the flywheel spokes in the manner shown in the accompanying illustration, which is an old tracing made at the time of the alteration.

Between this extra boss and the rim of the wheel were placed eight 2½-in. diameter radial stays, tensioned and fastened by nuts. These were placed midway between the eight arms of the wheel,



Views Showing Construction of Flywheel

which was built up of eight segments and had the following dimensions: diameter, 14 ft. 6 in.; rim section, 10x7½ in.; arms, 10 in. diameter. To the flywheel was bolted a gearwheel with 208 teeth of 2.77 in. pitch, which meshed with a wheel with 74 cogs for driving the line shafting in one of the weaving sheds. The other leading dimensions of the engine at the time of the smash were as follows: high-pressure cylinder, 19¼x30 in.; low-pressure cylinder, 26⅛x60 in.; diameter of high-pressure piston rod, 3⅝ in.; low-pressure piston rod, 3¾ in.; nickel-steel crankpin, 5 in. The engine was supplied with steam by either or both of two Galloway boilers, working at 105 lb. per square inch pressure.

In January, 1909, the crankpin broke, and caused considerable damage. The high- and low-pressure cylinders were broken, the beam was fractured and many other and minor parts were damaged. This accident was attributed to the fact that the crankpin was hollow; it had been taken from a larger engine and turned down to 4¾ in., and the pin being hollow, it was too little to hold.

In July, 1910, the cast-iron connecting-rod was found to be fractured, although at the time of the smash in 1909 it had been very carefully examined and no trace of a fracture was found. It was replaced by a steel rod which was on the engine at the time of the accident about to be described.

The equilibrium (or governor) valve was connected flange to flange with the engine hand-throttle valve, the governor valve being on the engine side. After the noonday stop, the engineer cracked the throttle open to warm up and ran the engine slowly for the afternoon load, there being no load on the line shafting at the time. The split-pin securing the connecting pin between the disk and the hand throttle-valve spindle came out, having worked loose, and the connecting pin, which must also have been a slack fit, dropped out of place and blew along through the flanged coupling into the equilibrium valve where it lodged between the valve and its seat, the throttle valve being disconnected from its spindle and dropping wide open.

The result was to allow a full head and pressure of steam through the wide open and disabled throttle and governor valves into the engine, which was without load. Therefore, before the engineer could get over the distance to the boiler stop valve, the engine had attained a speed that the patchy flywheel could not hold out against and it let go, doing considerable damage to the adjoining weaving shed, partially wrecking the engine room, smashing two looms and making a total wreck of the engine. Luckily, no one was injured and the presence of another engine saved the mill from total stoppage.

The writer is inclined to the opinion that the spokes would be the first to let go. It would appear to be extremely difficult to tension the eight strengthening stays previously mentioned to take an adequate share of the load and, if this theory is correct, they would be quite unable to handle the load suddenly thrown upon them by the failure, in the first instance, of one or more of the spokes.

London International Smoke Abatement Exhibition

From Mar. 23 to Apr. 4, this exhibition was held in the Royal Agricultural Hall, Islington, London. The last international exhibition of this character was held in London in 1881; and considerable progress has been made in the methods and apparatus for securing the smokeless combustion of fuel that have been worked out and applied practically in the 30 years that have elapsed. It was, of course, unfortunate that the preparations for the 1912 exhibition should have been overshadowed by the disastrous coal miners' strike, and it may seem somewhat ironical to hold a smoke-abatement exhibition in London when the chief problem confronting English manufacturers was "how to get coal to burn" rather than "how to burn it without producing smoke."

The participation of foreign manufacturers and inventors in the exhibition was not so great as was expected, many manufacturers stating that a fortnight's exhibition was too short for them to recoup themselves for the necessary expenditure. The strike also prevented some of the English exhibitors from sending their exhibits, owing to the curtailment of the railway service for goods. In spite of these difficulties an interesting show of smoke-abatement apparatus and appliances was obtained.

Conferences were held under the presidency of Sir William Ramsay, Sir William Richmond and Lord Justice Moulton, and a large number of interesting papers were presented. In a later issue a résumé of the papers and discussions will be printed.

Special Meeting of Mechanical Engineers

On Tuesday evening, Apr. 9, the American Society of Mechanical Engineers in New York City will hold a special meeting in honor of the Commission of the German Museum of Masterpieces of Natural Sciences and Technical Arts which is visiting this country to inspect industrial establishments, museums, libraries, etc. Dr. Oscar von Miller, member of the House of Lords of Bavaria and president of the Verein Deutscher Ingenieure, who heads the commission, will deliver a lecture on its work with special views showing the interesting features of the Bavarian Technical Museum which has no counterpart in the world.

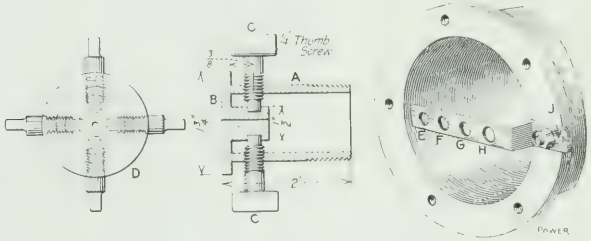
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Centering Device for Cylinders

The figures shown herewith illustrate a convenient device for centering cylinders which has been used by several engineers with very satisfactory results.

Referring to the illustration, *A* is a short piece of 1-in. wrought-iron pipe, one end of which is faced off. The other end is threaded as shown; *B* is a carrier for the centering cord or wire. Four holes are tapped in the piece *A* at right angles, as shown in the end view *D*. By means of the thumb-screws *C*, which fit in the groove in *B*, adjustment of the cord is made.



DETAILS OF CENTERING DEVICE

On the cylinder head is a piece of wrought iron, offset as shown. *E, F, G* and *H* are holes tapped for 1-in. pipe to receive the piece *A* and provide for its use with different diameters of cylinders. The slot *J* is for bolting on by the cylinder-head studs and to provide smaller adjustments than those given by the tapped holes. Final adjustment is made by the thumb-screws *C*.

The offset holder is bolted at one side only and provides convenient access to the cylinder.

CARL L. SVENSEN.

Tufts College, Mass.

Asbestos Drum Covering

In our plant we have a 200-hp. boiler, the drum heads of which stick out past the brickwork. I tried several ways of coating the heads with asbestos, such as mixing it to the consistency of putty by adding water and applying this by molding it into small balls the size of a marble and tossing them against the head, but they would not stick.

Then I tried painting the head with shellac and applying the asbestos dry, but this did not work. I did not have a supply of litharge. Next I mixed the asbestos with water so that it would just about run. I used a pointing trowel and, placing a small amount on it, threw the mixture against the heads in spots. When this dried I went over it again in the same way until the head was well covered. Several thin coats were applied, letting each one dry well, until I had the covering the thickness required.

When applying the last coat I troweled it down and then, taking a whitewash brush, wetting it and rubbing it over the last coat, and following it up with the trowel, I got a fine finish, almost as smooth as glass.

HARRY E. KOFFEL.

Doylestown, Penn.

Packing and Gasket Cutters

Nearly every engineer has tools of his own invention, which, although not suitable for the market, are often very handy to the man on the job.

I have a number of small belts, 3 and 4 in. wide, which run very tight on the pulleys. In the case of these belts coming off, I use a hook to pull the belt up on the pulley. It is made of ¾-in. pipe, as shown in Fig. 1, and can be easily pulled out of the hand in case it catches in the pulley.

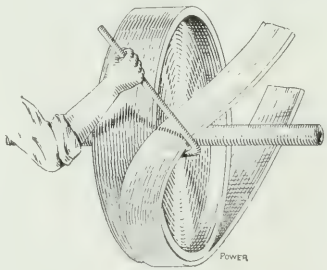


FIG. 1. BELT HOOK

Another useful tool is made of short pieces of brass tubing, a number of different diameters. In cutting belt holes in gaskets, markers, etc., these pieces of tubing are handy. I use a piece of wood and a hammer when cutting, as shown in Fig. 2, as the wood protects the tube-edge. I have an old file connected to a hard-wood board, as in Fig. 3, for cutting spiral packing to short lengths. The file edge, which comes against the board, is ground down to a razor edge. It can be used in cutting small belts.

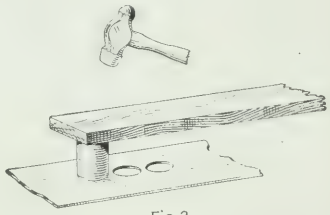


Fig. 2

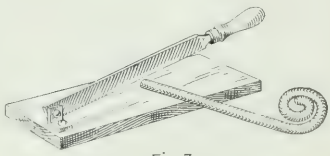


Fig. 3

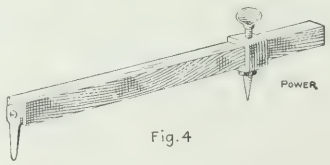


Fig. 4

GASKET AND PACKING CUTTERS

For cutting large gaskets, I took an old jackknife blade and chiseled a hole ⅛ in. in diameter and 2 in. from the end, sharpened the back and front edges and attached the blade by means of a short screw to a piece of hard wood 1 in. square and 2 ft. long. In a piece of soft iron ¾ in. wide and ½ in. thick, two holes were drilled, one ½ in. from the end and the other 2 in. from the same end. I then bent the iron to fit the piece of wood and threaded the holes. A bolt sharpened on the end fills the lower hole, and a thumbscrew fills the upper hole. The tool is shown in Fig. 4.

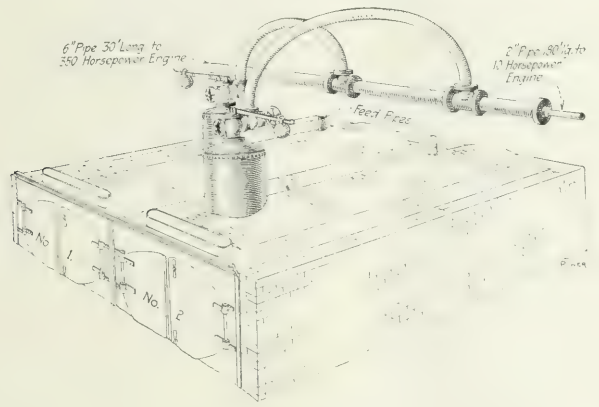
To cut any diameter of washer, move the slide containing the pivot to the point desired and move the knife in a circle.

A. D. PALMER.

Roxbury, Mass.

Boilers Transfer Water

The accompanying diagram shows the steam connection of two boilers. If both are filled nearly to the point where the high-water alarm whistle will blow, and the water from both boilers is then shut off, after 10 or 15 min. No. 1 will begin to blow with high water and the water will gradually go down in No. 2 boiler. There is no connection between the boilers with the exception of the 6-in. steam header.



PIPING OF THE BOILERS

I say the pressure of one boiler holds the steam back in the other boiler, but the other engineer says it is because No. 1 boiler is the best steam maker. They are both connected to the same stack.

I would like to hear from engineers who have had similar conditions and have found out the cause.

W. E. WARNER.

Springfield, Mass.

Arrow Pointed Wrong Way

Some time ago, when enlarging a power plant and using the loop system of high-pressure steam distribution, it was necessary to use reducing valves at four points to supply the various boiler- and engine-room auxiliaries, and for factory purposes.

The reducing valves were ordered and put in place with a stop valve connected to the reducing valve and between it and the boilers. On three of the lines the valves regulated to a nicety, reducing from 175 to 80 lb. gage; but the fourth valve would not give satisfaction, having a tendency to stick wherever it was put.

Thinking that it was sticking in the sleeves somewhere inside, I had it taken down and eased off; on putting it back I was disappointed in finding no improvement. I then removed the asbestos covering, thinking that it may have been put in wrong, but the arrows showed that it was properly installed. The other three reducing valves were giving splendid satisfaction in their respective branches, so I decided next week-end to take one of the good valves down and check it with the faulty valve, but found everything identical in construction. I then noticed that the opening in the valve appeared to be in reverse position to the good one, and so without doing anything more I put it back in a reverse position to the arrows showing on the valve body. It now works properly along with the others.

P. BROCKIE.

Montreal, Can.

Wrong Holes in Flange

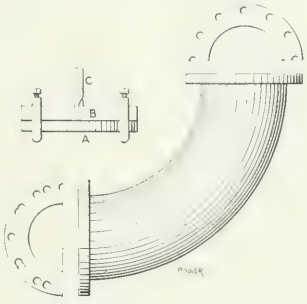
At a factory power plant an unaccountable incident occurred which caused the loss of half a day's production of about 1000 looms.

A crack developed in a 10-in. cast-iron elbow in the main steam pipe and an order was made out for one long-radius, cast-iron elbow with the flanges drilled for twelve ¾-in. bolts, the holes to be drilled on the seam. This meant that the starting point for drilling must be at the joint, where the pattern came together in the mold.

In anticipation of the arrival of the new elbow, staging, chain blocks, rope slings and some new flange bolts were gotten ready so as to do a quick, thorough job. The elbow came by express and at shutting-down time the boiler stop valves were shut, the drip valves were opened and the cracked elbow was soon on the floor.

When the new elbow was hoisted into place it was found that one of the flanges was drilled from a 10-hole template. If the requisite tools had been on the premises the adjoining pipe flange would have been used as a template and a ⅞-in. drill run through the bolt holes and through the flange of the new elbow by hand. The new flange was marked while in position and the elbow taken to a local machine shop to be drilled.

As a guide for the drill a flat piece of iron about 1 in. thick was used and drilled through with a ⅞-in. drill. This hole was placed directly over the marks on the flange and clamped in place. Then another hole was drilled through the guide and flange, care being exercised to keep the flange, which was 1⅛ in. thick, level. This method of drilling the holes proved very effective, especially where the holes were drifted less than the diameter of the drill, and there was very little chipping and filing to be done.



FLANGE AFTER DRILLING

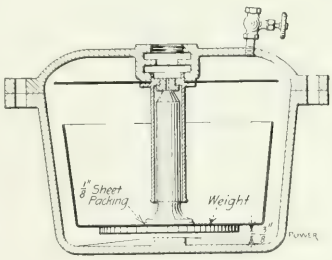
The sketch shows the elbow and flange *A* after it was redrilled, also the guide *B* clamped in position to guide the drill *C*.

J. W. PARKER.

Clinton, Mass.

Traps Did Not Work

I am employed at a mill that has been "grinding" 54 years and have found many traps of bygone days which had to be repaired and changed. These were of the bucket type and would not work on the 90-lb. duty, being made for less.



WEIGHTED BUCKET

The changes consist of making the valve seat with a much smaller bore and adding a cast-iron weight under the bucket, as shown in the illustration.

We had quite a few overhauled and they worked well, but there was one trap which would not shut after open-

ng. I looked it over and found that the ucket had a 3/8-in. drop when full. I educed the drop to 1/8 in. and then subtituted a 1/64-in. gasket in place of the 8-in. sheet packing at the joint of the tem and bucket, thus lessening the mount of water left standing in the ucket after the trap discharges. The rap worked well after these changes.

These same bucket traps gave some rouble by getting air-bound and not pening. A way out of the difficulty, and ne well worth while, is shown in the ketch. Drill and tap a hole in the over for a 1/8-in. iron pipe. Then inert a 1/8-in. extra-heavy close nipple and crew a 1/8-in. valve on the nipple, and et the valve remain open all the time, ust enough to "sizzle." A lot of kicks nd troubles will then vanish as the traps rill never get air-bound again.

FRANK MARTIN.

College Point, N. Y.

Does Not Fear Central Station

If one-half the time wasted in berating he central station, and moaning over ow wages were spent in improving plant onditions, there would be no kick comng to either the engineer or the emloyer. Those who buy engine-room quipment generally buy on a guarantee f efficiency, and have a right to expect egular statements from the engineer, as o whether they are getting what they ave paid for.

I am operating an ordinary high-speed lant. My wage account for the night nd the day fireman and self averages $3 er day more than the cost of fuel for he 24 hours. The average cost for power as been $0.0164 per kilowatt-hour from uly, 1911, to January, 1912; this charge ncludes the cost of fuel, water, waste, il, wages and interest, depreciation, inurance and taxes. The last four items mount to $4.22 per day. The average oad is 1400 kilowatt-hours per day—60 er cent. power factor.

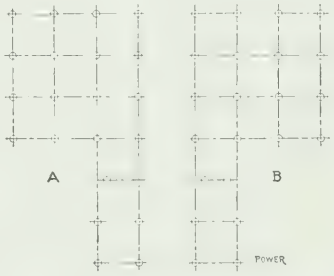
Considering heating as an expense, the annual saving over central-station power amounts to $4059.50, or a rate of interest of 24 7/10 per cent. per annum on the investment. I am not losing any sleep on account of the central station or wages. My daily cost and coal-analysis card are shown herewith.

D. L. DUNLAP.

Detroit, Mich.

Template Set Wrong

An incident was once brought to my attention that was a good example of the penny-wise, pound-foolish methods of some managers in employing incompetent men to do the work of a skilled engineer.



TEMPLATE WAS REMOVED

A company had been organized to build an industrial plant and the machinery had been ordered from a concern which proposed to furnish a competent erecting engineer, the purchasing company to pay him $7 a day and expenses.

The wise manager thought that this was a superfluous luxury as he had a local genius, who had never had any experience with the machinery to be installed. In the equipment was a machine requiring quite a substantial foundation, with the foundation bolts arranged as shown at *A*, in which the four end bolts were to be 8 in. lower than the others.

The makers furnished the template, fully marked, knocked down and crated and also a blueprint showing clearly the proper way to assemble it.

The local genius arranged the template as shown at *B*, and at last accounts it was over the foundation hole, with the foundation bolts in place and everything ready for the concrete work.

As the four end bolts are to hold down a Corliss steam cylinder, and as they are 16 in. too high, besides being on the wrong side, there will doubtless be an interesting time when the machine is placed over the foundation.

J. T. WILLIAMS.

Brownsville, Tex.

Thermometers on Condensers

Did any reader ever stop to think how many tons of coal could be saved in his plant by the investment of a few dollars in thermometers? During the winter, when the circulating water has a temperature of from 32 to 40 deg. F., it is an easy matter to lower the temperature of a condenser below that necessary to produce the required vacuum. Placing a thermometer on the discharge pipe of each condenser and regulating the circulating water according to its reading will result in raising the temperature of the hotwell a matter of 3 per cent.

Assume a daily output of 500,000 kw.-hr. at, say, a water rate of 16 lb. per kilowatt-hour, and see what a 33-deg. rise amounts to in tons of coal burned per day. These thermometers will also save on the amount of circulating water pumped and show whether a low vacuum is caused by high temperature or air leaks.

I have found that there is no use having a discharge temperature lower than 85 deg. F. on reciprocating work. Of course, the thermometers are useless unless looked at frequently. One might even go further and suggest recording instruments.

E. H. LANE.

Kansas City, Mo.

FORM 20

THE EDMUNDS & JONES MFG. CO.
DETROIT, MICH.

SAMPLE OF NAGOLA STOKER BOUGHT FROM DETROIT & PITTSBURG COAL CO
OUR ORDER No. 3034 CAR No. C&O-33178 WEIGHT 100,000
BASE PRICE PER B. T. U. DELIVERED .075 per 13600 PRICE PER TON, A BASE .77
COST TO LN. OAD PER TON .020 TOTAL COST PER TON 2.37
ANALYSIS MADE BY RWR DATE 12-22-11

MOISTURE		HIGH	75.75	°F.
VOLATILE CARBON	%	INITIAL	71.00	°F.
FIXED CARBON	%	RISE	4.75	°F.
ASH	7.7 %	RADIATION	0.025	°F.
SULPHUR	1.2 %	CORRECTION	.02985	°F.
FERRIC OXIDE	%	CORRECTED RISE	4.7765	°F.
PHOSPHORUS	%	FACTOR	3117	
B. T. U. PER POUND COAL		13,953		
B. T. U. PER POUND COMBUSTIBLE				
CALORIMETER	PARR STANDARD.			

NOTES

FORM 25-M

THE EDMUNDS & JONES MFG. CO.
DAILY COST OF POWER & HEAT

DAY ENDING		RECORDED BY	
DAY COAL	LBS.	COAL PER K.W.HR.	LBS.
NIGHT COAL	LBS.	COST OF COAL	
TOTAL COAL	LBS.	COST OF OIL & WASTE	
WATER	CU. FT.	COST OF WATER	
CYLINDER OIL	PINTS	COST OF SERVICE	
ENGINE OIL	PINTS	COST OF REPLACEMENT	
WASTE	LBS.	FIXED CHARGE	
CURRENT	K.W. HRS.	TOTAL DAILY COST	
REMARKS:—		NET COST PER K.W.HR.	
		COAL COST PER K.W.HR.	

DAILY COST AND COAL ANALYSIS CARDS

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Transmitting Capacity of Pulleys

Recently I criticized a paper on the relative power transmitting capacity of cast-iron, paper, wood and cork-insert pulleys, read by Prof. Sawdon, of Cornell University, before the National Association of Cotton Manufacturers.

In replying, Prof. Sawdon fails to explain why his tests show totally different results from those obtained by Prof.

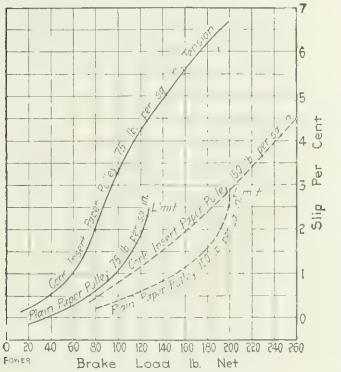

Cast Iron
Cork Insert Paper Pulley 75 lb. per sq. in.
Cork Insert Paper Pulley 132 lb. per sq. in.
Plain Paper Pulley 75 lb. per sq. in.
Plain Paper Pulley 132 lb. per sq. in.
Slip Per Cent
Brake Load lb. Net
POWER

FIG. 1. SLIP CURVES FOR PAPER PULLEYS WITH CORK INSERTS

Charles M. Allen, of the Worcester Polytechnic Institute, and George H. Perkins, of the Lowell Textile School, but, in taking exception to my criticism, calls attention to a few matters of minor importance, to which I reply as follows:

1. I did not include in the report of tests made at the Worcester Polytechnic Institute the tests of the vulcanized fiber pulley as I considered the results obtained of no value to anyone.

2. Although Prof. Sawdon writes that in my reply I cited but one set of tests: namely, those made at the Lowell Textile School, a reference to the paper, herein quoted, will show his error.

"As the results described therein do not fully accord with those obtained in similar tests made at the Worcester Polytechnic Institute, at the Lowell Textile School and with other pulleys in use under factory conditions, careful consideration and discussion seem desirable in order that we may consider the reasons for the differences referred to and establish the facts in the matter."

3. Replying to his statement that, "The losses between the belt and the pulley in a practical transmission rarely exceed about 2 per cent. and are often less," I refer again to his original paper in which is stated: "Many kinds of service demand at times overload capacities as much as 50 per cent. of the normal load," and I would like to know if these overloaded drives come within the class referred to in which the slip does not exceed 2 per cent.

4. While it is true that F. W. Taylor recommended a belt tension of 200 to 225 lb. for use on plain cast-iron pulleys upon upright machine-tool drives, neither he nor any other engineer will object to a lower belt tension when practicable and, as bearing on this, it may be of interest to note that Prof. Sawdon's tests were started at a belt tension of 37½ lb.

Equipping pulleys for such a test with but one-half the required cork area is

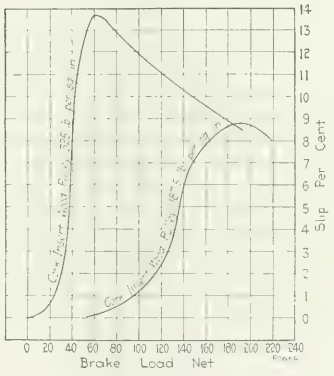


FIG. 2. SLIP CURVES FOR WOOD PULLEYS WITH CORK INSERTS

bad enough, but to allow the corks to project 1/11 and 1/13 in. respectively, which projection tends to prevent the belt from making contact with the remainder of the surface of the pulley and thus reduces the actual area of pulley surface in contact with the belt, is still more disastrous to correct conclusions.

Furthermore, it was stated that: "unfortunately in the paper and in the corked-pulley tests the capacity of the machine did not permit of a high load being carried to determine the maximum values of the coefficient of friction and the corresponding slip," whereas upon examining the full report on file with the association it is found from the data sheets and diagrams that no reference is made to the behavior of plain paper pulleys at a slip exceeding 2.8 per cent. but the cork-insert paper pulleys are carried to loads of nearly double and a slips that reached nearly 7 per cent.—a somewhat surprising circumstance in the light of the foregoing quotation as to the limit of the capacity of the machine. I should like to know why Prof. Sawdon omitted to carry the paper-pulley tests beyond the low point at which these tests were apparently stopped and yet carried the cork-insert pulleys to the high point.

To make this point clear I submit a set of comparative curves (Fig. 1) taken from separate sheets of the unpublished portion of the original report, which speaks for itself.

Again, the cork-insert pulleys tested were not only equipped with but about one-half the required area of cork, but the cork was used under but 19 per cent compression instead of 33⅓ to 50 per cent. as has been found desirable and is common practice.

I also submit another diagram (Fig. 2) from his unpublished curves of cork-insert wooden pulleys at belt tensions of 37½ and 187½ lb. respectively. This diagram shows that a pulley with a belt tension of 37½ lb. will lose in efficiency to a point of 14 per cent. slip with a load of 60 lb. and then gain in efficiency under an increasing load until the slip is but 8.75 per cent. with a load of 180 lb., at which point the pulley with a belt tension of but 37½ lb. will equal in efficiency a pulley operating under a belt tension of 187½ lb.—a result that seems as improbable as it is different from those obtained by others.

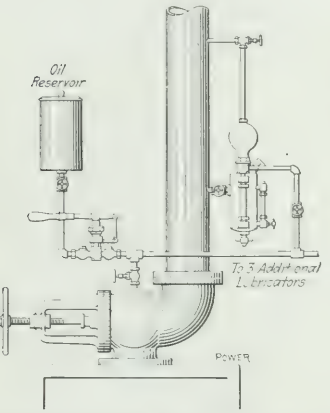
LAWRENCE WHITCOMB,
Treasurer, The Cork Insert Co.
Boston, Mass.

Oil Pump and Lubricator Filler

Mr. McGerry's letter in the Jan. 2 issue described an oil pump and lubricator filler. I have used a similar device for years, but I always connect the oil pipe to the plug at the top of the gage-glass, as shown in the accompanying figure, drilling and tapping the plug for a ¼-in. pipe, thus leaving the filling plug and hole in condition to be used at any time, should the pump fail to

vork, or anything else go wrong. Another advantage of this arrangement is hat it does not mar the threads or seat f the filling hole, and the lubricator can e filled by hand in the usual way.

Mr. McGerry advises drawing out the vater in the lubricator body and the ondenser through the drain-cock. This s poor practice. The condenser should ot be emptied or allowed to get hot. Further, it is not necessary to drain the ody through the drain-cock. Simply lose the oil sight-feed valve and leave he water-feed valve open. Then, forcng the oil into the body of the lubriator will force the water out and up hrough the condenser and condenser ipe, into the steam pipe, both being kept old with the cold water in the body. Closing the oil valve at the pump will hen leave the lubricator ready to work t once.



Arrangement and Piping of Oil Pump

I have a hand-lever oil pump, similar o that shown in the figure, attached to a 5-gal. reservoir supplying cylinder oil to four lubricators, of from 1 pt. to ½ gal. n capacity, and located variously from 30 to 60 ft. from the pump, all fed hrough a ¼-in. pipe, with a valve close o each lubricator. The oiler opens the valve leading to the lubricator he wishes o fill, and gives the oil pump the required number of strokes. He then shuts the filling valve in the oil-supply pipe, and the lubricator is made ready for service again simply by opening the oil-feed valve in the sight-feed glass, which, of course, was closed before the pump was used.

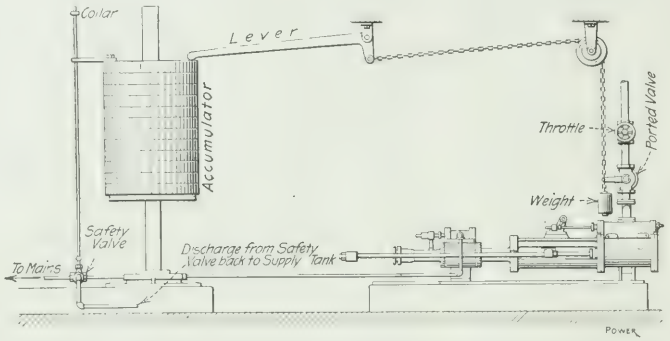
The ½-gal. lubricator sometimes gets hot, generally through carelessness, and I find that the quickest way in which to cool it is to close the sight-feed valve and force cold cylinder oil through it; the hot oil goes out through the condenser and condenser pipe into the steam pipe and thus it is not altogether wasted.

W. E. Stickney.

Prince Albert, Sask.

Step Bearing Pressure Regulator

Mr. Payne, in the Feb. 20 issue, details a very ingenious automatic pump control for a hydraulic pressure system. The apparatus looks to be very flexible in that it would be capable of controlling the pumps in remote locations with relation to the accumulator. The design of pump control herewith submitted is not new; it has been in successful operation in a cottonseed oil mill for several years.



Arrangement of Automatic Pump Control

By the use of the lever with the short projection, a reducing motion is secured whereby the ported valve in the steam line is controlled. This valve acts as an auxiliary to the throttle, which latter is set by hand to admit the required steam to run the pump at the desired speed.

The operation is simple and positive. As the accumulator rises the ported valve is closed through the medium of the chain and lever. In case of accident to the closing-off device, the accumulator rises to the collar on the safety-valve rod and the pump discharges direct to the supply tank.

F. C. Holly.

Memphis, Tenn.

Will the Injector Work?

In reply to Mr. Brouse's inquiry on page 340 of the Mar. 5 issue, I would say that while there is no doubt that two injectors can be made to feed at the same time, the layout of piping shown would hardly commend itself as being the best method for installing injectors in parallel. If the cut accompanying his letter is referred to, it will be seen that the two streams of water from the injectors will meet "head-on," so to speak, and then make a 90-deg. turn into the pipe leading to the boilers.

A much better arrangement would be to bring the line from one injector into the feed line with a 90-deg. elbow, and the line from the other injector into the feed line at a different point with a Y-fitting. If the piping is installed in this manner, I do not think that there will be any difficulty encountered in operating both injectors at the same time.

W. L. Durand.

Brooklyn, N. Y.

I do not think the injectors will work; at least, they will not supply both boilers. The injectors are fitted with 1¼-in. steam and water pipes; therefore, only enough steam pressure will be had to work one injector, and there will be only enough water for one.

If Mr. Brouse will tap the city main with a 2-in. pipe and then reduce at the connections of the injectors to 1¼ in. and if he will tap the boiler with a 2-in. steam-supply pipe, and connect the discharge of the two injectors with a Y instead of a tee, it might be possible for them both to work at the same time, although under some difficulty.

I would advise that Mr. Brouse install the injectors separate from each other and also from the pump.

G. H. Robertson.

Datura, Tex.

In the issue of Mar. 5, J. L. Brouse asks, will the injector work?

I see no reason why it will not, as the piping is proportioned about right. A much better layout, however, would be to do away with the tee between the injectors on the discharge and replace it with a long-sweep, double-branch elbow. This would lead the discharge from each injector in a more direct path to the boilers instead of allowing the injectors to butt against each other.

George H. Handley.

Newburgh, N. Y.

Most assuredly the injector will work. He can work both injectors at the same time, he can work either one at the same time as the boiler-feed pump is working, or, if he cares to do so, he can work both injectors and the pump at the same time.

In the plant where I am employed there is almost identically the same piping and pump connections, and I have

tried them repeatedly and find it possible to work them in any combination or all together.

H. L. BURNS.

Caruthersville, Mo.

I do not think that the two injectors can be made to operate together; that is, if the second one is started it will break the stream from the first. I also think that the 1¼-in. pipe for the suction is not large enough for the two injectors. I believe that if the injectors were provided with separate suction pipes there will be no trouble.

WILLIAM H. KUCHENBROD.

Louisville, Ky.

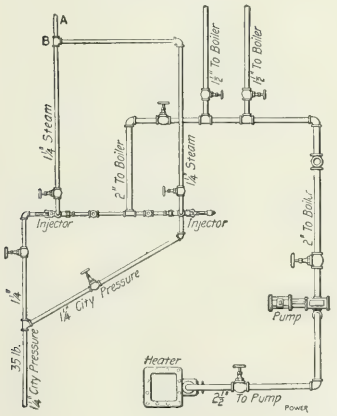
My theory is that the injectors will work, but they will not give the proper efficiency. My plan would be to put a Y next to the 2-in. elbow and have separate pipes to each injector, forming a gradual bend from the Y to the injector, and have the check valve not closer than 2 ft. to the injector. I have seen lots of injector troubles caused by not being connected properly and find that it is best to eliminate all elbows as far as possible.

WILLIAM T. HURD.

Bellefontaine, Ohio.

Answering J. L. Brouse I say that the two injectors will work on the same line at one time, providing steam line *A* be of 1¾-in. pipe to the tee *B*.

It seems to me that a better arrangement would be to have two suction pipes from the injectors running to a tank, and the city mains empty into this tank with a float valve to regulate the amount of water admitted to it.



ARRANGEMENT OF PIPING AND INJECTORS

F. P. SMITH.

Roswell, Ind.

See the Hump

The hump in Phil Lighte's indicator diagrams, shown in the Mar. 5 issue, was undoubtedly caused by lost motion in the indicator piston or spring. If he had examined it closely he would probably have found some part not screwed up tight.

The pressure of the steam during expansion is balanced by the pressure of the indicator spring under compression. As soon as the atmospheric line is passed this changes, the pressure of the atmosphere on top of the piston becomes greater than the steam pressure in the cylinder, and the difference in pressure is balanced by the spring now placed under tension.

At this point any lost motion is bound to show itself and in this case it did on both diagrams, illustrating what a little lost motion in an indicator will do.

JOHN BAILEY.

Milwaukee, Wis.

Fuel Economy and CO_2 Recorders

The exceptions taken by Charles M. Rogers in the issue of Feb. 20, to my objections to the intermittent type of carbon-dioxide recorder in the issue of Jan. 23 are interesting, but Mr. Rogers has failed to give any reason why an intelligent fireman equipped with a dollar watch cannot conduct the few simple experiments necessary to establish the time elements of the interval during which gas is not being drawn into the apparatus.

The visibility of a single moving part of the recorder, even if it is only the chart and pen, establishes a base from which it is readily possible to work back through the entire sequence of operations and establish their time elements upon a basis which will enable the fireman operating any one or more of the boilers or furnaces connected with the apparatus to dodge the record. A variable time interval might increase the difficulty of establishing the time elements of the operations, but it would not make it impossible. Taking the samples in rotation from a number of furnaces increases the time interval between the samples from the individual furnace and gives the fireman a much better opportunity to obtain high record.

The possibility of dodging the record of the intermittent type of apparatus depends, not upon the shortness of the interval during which gas is not being taken into the apparatus, nor upon the variation in the length of this time, but upon the willingness of the fireman to ferret out the weak point by the expenditure of a little time, trouble and thought.

One and a half or two minutes is a very considerable length of time to pass between the end of one sample and the starting to take the next sample. Mr. Rogers can readily convince himself of the length of this interval by timing it. Pearl divers go down in 30 ft. of water, gather a load of shells and return to the surface in less than two minutes.

It makes no difference whether the gas is bubbled up through the solution or not; a fresh solution will take up the gas quicker than a nearly saturated one. Hence the time during which the gas is in contact with the solution depends upon the slowest acting solution.

The slowest solution should determine the length of time the gas is in contact with its surface or the length of time it takes to bubble the gas up through it. Any recorder which neglects the difference between fresh and partially saturated solutions will give an incorrect record.

A. D. WILLIAMS.

Cleveland, Ohio.

Why American Workers Excel

In the issue for Feb. 20 an article with the above title has a few statements which are worthy of a little consideration.

It is quite possible that the men in the Providence shop were studying geometry while the lathe was taking a cut, but they must have had a different kind of foreman to deal with than I ever had, or they would have got the book taken away; I had to do my figuring on the quiet. Nearly all of the young men who worked in the same shop with me across the water attended evening classes and were studying some subject connected with their work.

I have worked with young men over here whose only thought seemed to be knocking off time, so that they could get out on the corner with the boys.

As to cricket and football, a young man's efficiency is not likely to be impaired by taking an interest in healthy athletics. For that matter, our young men crowd to baseball games; is there any other subject talked of during the baseball season and does it do any harm?

If horse racing is as deeply rooted in the minds of young men as the article states, they must have changed considerably within the last few years; racing was a subject little talked of when I served my apprenticeship.

In view of all these deficiencies some will wonder how such companies as Harland & Wolff, Fairfield Shipbuilding Co., Palmers Shipbuilding Co., or any of the other large shops continue to do business. The men in responsible positions in those places certainly are paid more than 30 shillings (about $7.50) per week, and as far as I ever knew, there are few £5 ($24.33) a week jobs going begging, in spite of the fact that the men are smoking instead of studying algebra.

J. Y. GILLESPIE.

Westchester, N. Y.

Cost of Power in New England Mills

Concerning Franklin Van Winkle's criticism in a recent issue of drawing comparisons between the cost of indicated horsepower and the cost of electric horsepower delivered on the switchboard, his point is, as I understand it, that the comparative cost of power should be based on the amount of power delivered to the machines. This comparison can very readily be made, as follows:

First, assume that the electric company charges $30 per kilowatt, or $22.50 per electrical horsepower per year, for current measured at the switchboard in the mill. Further assume that the machinery is driven by electric motors arranged for group drive; that is, each motor drives several machines so that the capacity of the individual motors might be 50, 100 or 150 hp. With this arrangement a portion of the shafting will naturally be eliminated below what would be required with engine-belt drive.

At full load, the efficiency of these motors would not be better than 88 per cent., so that there is a loss to begin with of 12 per cent., for which the purchaser must pay. Let the energy loss between the switchboard and the motors in the wiring be 3 per cent. and the friction loss in shafting 15 per cent. These total up 30 per cent., which is a conservative and fair figure as actually found in practice. This means that the purchaser or consumer must pay the electric company for some 43 per cent. more energy than is actually delivered to the machines.

In the case of the engine-belt drive, the friction loss in the Fitchburg Yarn Co. plant has been measured and found to be 418 hp., or 24 per cent. of the total full load. This figure was ascertained by stopping all of the machines and running only the shafting and belts on idle pulleys. Deducting this friction load, which, it may be noticed, includes losses within the engine as well as jack, from the total indicated horsepower at average full load leaves 1326 hp. as the actual amount required at the machines. Now, as the losses with the electric drive are 30 per cent., this means that in order to deliver 1326 hp. to the machines the consumer would have to pay for 1894 hp. at the switchboard, which at $22.50 per horsepower would make a yearly rental of $42,615.

As indicated, 1326 hp. at the machines means 1744 i.hp. in the case of belted drive and multiplying 1744 hp. by $16.68, the yearly cost per indicated horsepower, makes a total yearly cost for power with belted drive of $29,090, or $13,525 less than the cost for electrical power at $22.50 per horsepower delivered at the switchboard in the mill.

Furthermore, if the consumer were buying his power, his heating item would be extra, as the 58c. cost was for coal only and contained no part of the operating and fixed charges. Making such steam for heating and for special manufacturing requirements in a special plant in conjunction with buying power from outside would add fully a dollar more per horsepower, or $1744, making the ultimate gain derived by the independent plant $15,269 yearly.

There should be a further charge against the electric drive for interest and depreciation on the heavier investment required for the motors, the switchboard and the wiring installation, which would be much greater than the saving due to the omission of the head shafts and some few line shafts with the belted drive.

The best data I have along this line relate to a large New Bedford mill which has both the mechanical transmission and the electrical drive, and where it was found that for the former it took 1 i.hp. to drive 4.5 looms, while for the electric drive the same power was consumed to drive 3.4 looms. The machines to both were identical as was also the class of goods made.

H. G. Brinckerhoff.

Boston, Mass.

Central Station vs. Isolated Plant

I have taken much interest in the discussion of the above topic. I am one of the "terrible, heartless and unprincipled" central-station solicitors, whose hand, according to some people, is raised against every isolated-plant engineer.

While I am at all times anxious to secure any additional power business for my company, I always try to show the conditions as they exist, and as they are most likely to be when buying power from my company.

There are a great many cases where it is a waste of time and energy for the central-station solicitor to figure on replacing private plants; in others, it is just the reverse. I recently had two cases which illustrate the uselessness of trying to win over an isolated plant. In the first case the plant owner has, and is making, money. He says that he takes a pride in having one of the finest plants in the country for its size, and that, although it might cost him $50,000 more per year to produce than to buy current, he would still run his own plant.

The other case is that of a large manufacturer who has factories in several cities and has recently established a large branch factory in Minneapolis. Some time ago his central-station service was unsatisfactory, and now he brands the whole fraternity of central-station solicitors as unreliable.

He has a very good plant; in fact, his power equipment is in duplicate. There are two engines, either of which can easily carry the load. His chief engineer expresses the belief that central-station service would be more satisfactory and cheaper than their plant, but to no avail. This factory closes at 5 p.m. and keeps a night engineer on the job running an engine until 12 p.m. to light a sign requiring 2 per cent. of the rated output of one generator rather than buy service from the company. This is an instance where prejudice runs away with judgment.

Recently I replaced a plant where it would have caused me genuine regret if the engineer had lost his position. I told the owner of the factory what a wide-awake engineer I thought he had, and asked what was to be done with him, when the new power should go in. He said he realized he had a good man and expected to have him look after the electrical equipment, shafting and machines and the steam heating used in the process of manufacture and in heating the building. This engineer will have a more pleasant job, with fully as good pay, shorter hours and very little, if any, Sunday work.

This man was "on the job" all of the time. While I was making an indicator test of the engine for power taken by various sections of the factory, he was an interested spectator and understood the meaning of the diagrams. He knew the approximate power taken by friction, that taken by various machines, the revolutions per minute of the engine, shafting, etc. The only reason the central station could secure the business was that the conditions of operation are such that it can sell them power cheaper than they can produce it.

This plant and its engineer are in marked contrast with some I have known.

V. S. Ball.

Minneapolis, Minn.

Impeller Turbine Pump or Air Lift, Which?

I would like to have Power readers discuss the relative merits of the impeller or deep-well centrifugal turbine pump and the modern air-lift for pumping water. Until a year ago we pumped by direct suction, but the water got so low that we had to adopt other means for lifting the water, so we installed one of the above systems.

The system has given good results, but there are those who think the other system would have been better. I would especially like to hear from those engineers who have abandoned one system for the other.

B. K. Goodman.

Reading, Mich.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Lining Up an Engine

When lining up an engine, should the line be centered from the counter bore or piston bore?

S. F. K.

Use the counter bore, particularly when lining up an old engine; the piston bore may be out of round.

Discharge Velocity

If a centrifugal pump with an 8-in. discharge delivers 1100 gal. per minute, what is the discharge velocity in feet per second?

S. M. M.

The rule for finding the velocity of the water in feet per second is: Multiply the discharge in gallons per minute by 231 and divide the product by 720 times the area of the discharge orifice in square inches. Applying the rule to your question:

$$Velocity = \frac{1100 \times 231}{720 \times 50.26} = 7 \text{ ft. per sec.}$$

Relieving the Pressure of the Exhaust

What provision should be made to relieve the back pressure on the exhaust of a condensing engine if the vacuum should fail?

C. M. H.

An automatic relief valve should be introduced in the exhaust line, with the valve so loaded that it will open when the pressure rises to a certain point.

Water and Superheated Steam

Can water exist in an atmosphere of superheated steam?

F. B. A.

Yes, just as ice can exist in the atmosphere of a hot summer day. Both the ice will melt and the water evaporate if they are given sufficient time.

Checking a Thermometer

How can the accuracy of a thermometer be checked?

J. McG.

If the point of immersion of the bulb is marked, place it up to the mark in melting ice and the point to which the mercury falls should be 32 deg. if a Fahrenheit scale or zero if a Centigrade scale. Then place it in boiling water at atmospheric pressure, up to the immersion mark. The mercury should rise to the 212 deg. mark if Fahrenheit or to 100 deg. if Centigrade.

Cement for Steam and Water Pipes

What is a good cement for steam and water pipes?

P. G.

Try a mixture of 2 lb. of paris white, 5 lb. of litharge, ¼ lb. of yellow ochre and ¼ oz. of hemp cut up small. Mix well with linseed oil to the consistency of putty and use at once. The materials can be mixed dry, and enough for immediate use can be made up with linseed oil. This cement will set under water.

Heating Surface of a Feed Water Heater

How much surface is required in a closed feed-water heater to heat 600 cu.ft. of water per hour from 40 to 204 deg. F., the temperature of the exhaust steam being 212 deg.?

J. P. K.

To find the square feet of heating surface, divide the weight of water passing through the heater per hour by the B.t.u. transmitted to the feed water per square foot of heating surface per degree difference in temperature between the steam and the water, and multiply the result by the hyperbolic logarithm of the difference between the steam temperature and the initial temperature of the water divided by the difference between the temperature of the steam and the final temperature of the water. A good average heat transmission for counterflow heaters with plain brass or copper tubes is 250 B.t.u. per square foot per hour per degree difference. Substituting figures, the rule would be expressed thus:

$$\frac{600 \times 62.5}{250} log_e \frac{212 - 40}{212 - 200} = \frac{37{,}500}{250} \times 2.65705 = 398.56 \text{ sq.ft.}$$

of heating surface.

Burnt Spots on the Commutator

What causes burnt spots on a commutator using carbon brushes?

A. G.

The most common causes are loose leads in the commutator lugs, high mica between bars, poor connection between the brush and the stud, and improper setting of the brushes. The trouble may be due to a combination of any of the foregoing causes.

Air Required for Engines Using Natural Gas

What mixture of air and gas will give the best results in a gas engine using natural gas?

W. A. B.

The relative volume of gas and air in the mixture depends upon the composition of the gas. The number of cubic feet of air can be approximated by multiplying the proportion of methane in the gas by 10, that of ethylene by 15, and that of hydrogen by 2½ and adding the results. For example, if the gas contained 90 per cent. of methane, 4 per cent. of ethylene and 1 per cent. of hydrogen, the following results will be obtained:

$$0.9 \times 10 = 9$$
$$0.04 \times 15 = 0.6$$
$$0.01 \times 2.5 = 0.025$$

and their sum, 9.625, will be the cubic feet of air required ordinarily per cubic foot of gas.

Synchronizing Lamps

When synchronizing with lamps, is it better to have the lamps bright or dark when the machine is in synchronism?

M. H. J.

It is safer to synchronize with the lamps bright, because a broken filament will not mislead one into throwing the machines together at the wrong time.

Synchronizing Generators

Which is preferable, synchronizing with lamps or by means of a synchroscope?

J. H. M.

The synchroscope or any synchronism indicator is preferable.

Choke Coil between a Rotary Converter and a Transformer

Can a choke coil be used between a rotary converter and its transformers so as to protect the machine in case it is thrown in when not in absolute synchronism?

W. K.

Such a precaution could be used and might be advantageous, but there should not be any necessity for it with modern apparatus for synchronizing.

New York State to Develop and Distribute Its Power

By a vote of 27 to 22, the Bayne water-power measure was passed by the New York Senate on Mar. 27. The Bayne bill provides that the state itself shall develop all water powers, generate electric power and transmit and sell it to the municipalities and factories of New York State.

The State Conservation Commissioners prepared the measure about two months ago, and it was necessary, in order to pass it before the closing of the session, to advance it out of its order and under suspension of the rules.

The Bayne bill met with considerable opposition, during which Senator Ferris offered a substitute bill. It was claimed by the opponents of the first-named bill that if the state develop its water powers and the electricity were distributed through private corporations, a large revenue would accrue to the state. Under the Bayne measure, declared Senator Ferris, the state-controlled water powers would develop only 220,000 hp.; that the state would be compelled to buy private water powers and establish steam plants to be able to furnish 1,500,000 hp., which is the amount used in the state.

Senator Bayne's explanation of the provisions of his bill is that it proposes to give the people the sole benefit from the development of the water powers of the state and the consequent generation of electricity instead of turning the state's resources over to private corporations. Under this bill the state will develop and distribute electric power made possible by the construction of water-storage dams directly to municipalities and factories without permitting private corporations to act as middlemen.

Allis-Chalmers Co. Reorganized

A new corporation will be formed of the Allis-Chalmers Co., according to the new reorganization plan, with a capital stock of $42,500,000; the stock will consist of $26,000,000 common and $16,500,000 seven per cent. accumulative preferred.

The present security holders will receive new stock in exchange on the following basis: for each $1000 five per cent. bond a total value of $1375, of which $1000 new preferred, $350 new common and $25 coupon Jan. 1 in cash; for each $100 par preferred stock upon payment of $20 in cash a total value of $110, of which $20 will be new preferred and $90 new common; for each $100 par value of common stock, a total value of $45, of which $10 will be in new preferred stock for $10 assessment and $35 in new common stock.

A voting trust of new preferred and common stock is to be created for five years with five voting trustees, to be appointed by the following reorganization committee: James M. Wallace, chairman; C. W. Cox, A. J. Hemphill, R. W. Leigh, J. H. McClement, W. E. Roosevelt and F. Vogel, Jr. It is planned also to obtain a friendly receiver, but he has not been named up to the time of going to press.

A "Carnival" of Boiler Explosions

The alarming frequency of boiler explosions is evidenced in the following press reports between Mar. 23 and 26:

On Mar. 23, five men were scalded and the boiler house at the Turner Coal Co.'s mine, near Evans City, Penn., was destroyed when one of the boilers exploded. The men were employees and were about to enter when the explosion took place. An investigation is under way, but the cause has not yet been determined.

A boiler used on the Melarky farm, near Marwood, Penn., owned by Denny & Cypher, contractors, on Mar. 25, exploded under a full head of steam. The crown-sheet was blown out, the grate bars were thrown in every direction and the fire was scattered over the belt house. No one was hurt and the rig and belt house escaped destruction.

On the same day, at Holcomb, Ala., five men were killed and three were seriously injured by the bursting of a boiler in the sawmill of Stewart & Hardin. The boiler room was completely wrecked.

The boiler of an engine running a circular saw on the H. H. Peterson farm, near Whiting, Iowa, exploded on Mar. 26, killing one man and injuring four others.

Six men were killed in the foregoing accidents and 12 men were injured. Elsewhere in this issue are recorded far more serious accidents and casualties, in which a locomotive boiler explosion at San Antonio, Tex., on Mar. 18, caused the death of 28 employees and injured over 40 others; at Salisbury, Md., 6 men were killed and 3 injured on Mar. 26; at Greentown, Penn., 4 were killed and 1 injured.

OBITUARY

It is with the deepest regret that we announce the death of Louis L. Rice, manager of *The National Engineer*. Mr. Rice was born in 1867 near Oxford, Chester County, Penn., where he received his primary education. From there he went to Philadelphia and finished his schooling and engaged in the printing business for some time, until in 1897 he started under the auspices of the American Order, the *Practical Engineer*. Mr. Rice continued to operate this publication until 1908, when, on account of ill health, he sold it to its present owners. After a couple of years of rest, Mr. Rice identified himself with *The National Engineer* as its general manager and continued in such position until his death, Mar. 18, 1912. Mr. Rice leaves a widow and three daughters to mourn his loss, and the many testimonials of esteem from those who knew him in a business way, are the strongest evidences of high character and integrity.

SOCIETY NOTES

The J. C. Jurgensen Branch of the Institute of Operating Engineers held its regular monthly meeting on Thursday, Mar. 28, at the institute headquarters, in the Engineering Societies Building, West Thirty-ninth St., New York. Over 75 members and friends were present. A. R. Maujer, member of the institute, gave a talk entitled "Ways and Means; How to Make Boiler-testing Apparatus and How to Use It." He showed how by the use of a little ingenuity and the expenditure of a small amount of effort and money an equipment for making reasonably accurate proximate coal analyses can be secured; that the heat value may be estimated from the proximate analysis in several simple ways and how the amount of air theoretically required by the coal may be ascertained. He also showed the principle upon which flue-gas apparatus is constructed, how it is manipulated and how the efficiency of combustion is calculated.

PERSONAL

Charles M. Rogers, formerly combustion engineer for the Detroit United Railway, Detroit, Mich., has accepted the position of superintendent of generation for the Empire District Electric Co., of Joplin, Mo.

Frank D. Chase, an associate member of the American Society of Civil Engineers, and architect of the Western Electric Co., has opened offices in the People's Gas Building, Chicago, for the practice of architecture and industrial engineering, making a specialty of manufacturing plants and mercantile buildings.

Dr. Rudolf Diesel, inventor of the engine bearing his name, is visiting New York and other cities in the United States. The purpose of Dr. Diesel's trip is to investigate the progress being made here with oil fuel. He may address several of the scientific bodies while here. The doctor says that America, as the land of oil *par excellence*, is destined to lead the world in the development of oil-fed motive power.

POWER

Vol. 35 NEW YORK, APRIL 16, 1912 No. 16

TO know when to close your mouth, and keep it closed, is an art. It may be born in a man; it may be cultivated.

The man who cannot control his speech—just allows it to constantly dribble—is a Blabber. His former friends shun him, he is a disturbing element, and he ruins his chances for advancement.

A certain chief engineer on taking charge of a large plant was told by the superintendent:

"I want you to run this plant as you think best. I look to you for results only, and if your present force is, in your opinion, either negligent or incompetent, fire any one of them, or all of them. I am interested solely in the plant's operating efficiency, and it's up to you to deliver the goods!"

Soon the chief noticed that when the old man made his daily rounds the assistant engineer would hold him up and appear to be criticising and complaining.

The superintendent was a busy man and, quickly tiring of the assistant's complaints, told the chief that if "the valves are not set properly, if you are evaporating only seven pounds of water per pound of coal instead of nine, hadn't you better quit? It's up to you, chief."

The chief indignantly denied that these conditions existed and asked the old man who was his source of information.

"There he is," said he, pointing to the assistant, "fight it out!"

Mr. Blabbing Assistant was instantly discharged. "There's no room for both of us in this plant," said the chief; "you wash up and quit!"

Being a wise chief, he called the force together that night and told them what he had done, and why he did it.

"When a man has any information to impart, he must come to me; I am running this plant. When there is a suggestion to offer, a criticism to make, tell me. I want your respect and your confidence, I want everything to run smoothly, but I am your representative in the business office; you keep out. That's all."

The Blabber always gets found out; it's bound to come and misfortune naturally follows. Fight shy of him. He cannot keep anything to himself, and therefore cannot be trusted.

When you enter the plant to work for the boss, whether it be morning, noon or night, forget your outside affairs; when you leave it don't discuss your chief and his method of running the plant; be loyal.

No man can tame his own tongue but himself; each man is its sole guardian. A shut mouth denotes firmness and determination; an open one gives the impression of weakness, and is often "operated" by a fool or a knave.

White River Power Development

Part of the system supplying light and power to Seattle and Tacoma.

The special features of the development are the unusually large storage capacity and the hydraulic turbines which are the largest of their kind. They are of the inward-flow reaction type and are capable of delivering 20,400 h.p. at a head of 480 ft.

The Pacific Coast Power Co. supplies light and power to Tacoma, Seattle and neighboring towns as well as to the interurban railroad connecting these towns. The system formerly comprised two hydro-electric plants, the Puyallup station of 14,000 kw. capacity, located on the Puyallup River, and the Snoqualmie station of 18,000 kw. capacity, on the Snoqualmie River; these being supplemented by several steam plants located in the cities.

These two hydro-electric plants, however, have practically no storage capacity and due to the irregular flow of the Puyallup and the Snoqualmie rivers it was difficult to handle the ever-increasing load. An idea of the increased demand may be gained from the fact that the population of Seattle and Tacoma, together with their suburban towns, increased from 118,000 in 1900 to 435,000 in 1910, and probably now reaches the half-million mark.

To meet this demand and to provide a large reserve capacity, the White River development was planned. This serves also as a balance wheel for the entire system, the other two hydro-electric plants being run at full capacity all the time while the governing is done by the White River plant. Moreover, the latter is so situated that its transmission lines tie into the system at its geographical center.

The White River rises in glaciers on the north and east slopes of Mt. Rainier and drains an area of about 400 square miles. The present development is about 10 miles east of Tacoma and 25 miles southeast of Seattle, the diversion dam being built at a point near the big viaduct of the Northern Pacific R.R., north of Bulkley.

Because of much drift being carried by the river at flood stages, the diversion dam has been specially constructed, being broad and low and designed so as to permit the passage of drift without injury. The dam is of concrete with rock-filled cribs, 352 ft. long, and has a spillway its entire length. Concrete wing walls flank the dam on both sides and are placed so as to prevent the stream from changing its course.

The intake is of concrete with the opening parallel to the flow of the stream and a heavy boom protects it against floating débris. It is provided with grooves for stop logs and has mechanically operated gates driven by a gasoline engine.

From the intake a timber flume, 28 ft. wide and 8 ft. deep, with a slope of 7 ft. to the mile, conducts the water one mile to the first of a chain of lakes or settling basins. The water passes through these at a low velocity and deposits practically all the silt before reaching the outlet. Sluice gates are provided so that the basins may be drained and the silt sluiced out.

An unlined canal about 7000 ft. long conducts the water from the last basin across the flat top of the plateau. It then flows into a timber-lined canal, having a drop of 111 ft. in 2 miles, from which it enters a natural valley. Part of this drop may be used in the future for the installation of a secondary plant.

The water flows a considerable distance through this natural valley, then through a wide cut having a slope of 5 ft. to the mile, finally emptying into Lake Tapp's reservoir.

This reservoir, or natural storage basin, formerly included Kirkley, Church and Crawford lakes, together with numerous small ravines. These were inclosed by a number of embankments and the level of the lakes was raised 35 ft., thus making a large reservoir covering an area of 6 square miles and providing a stor-

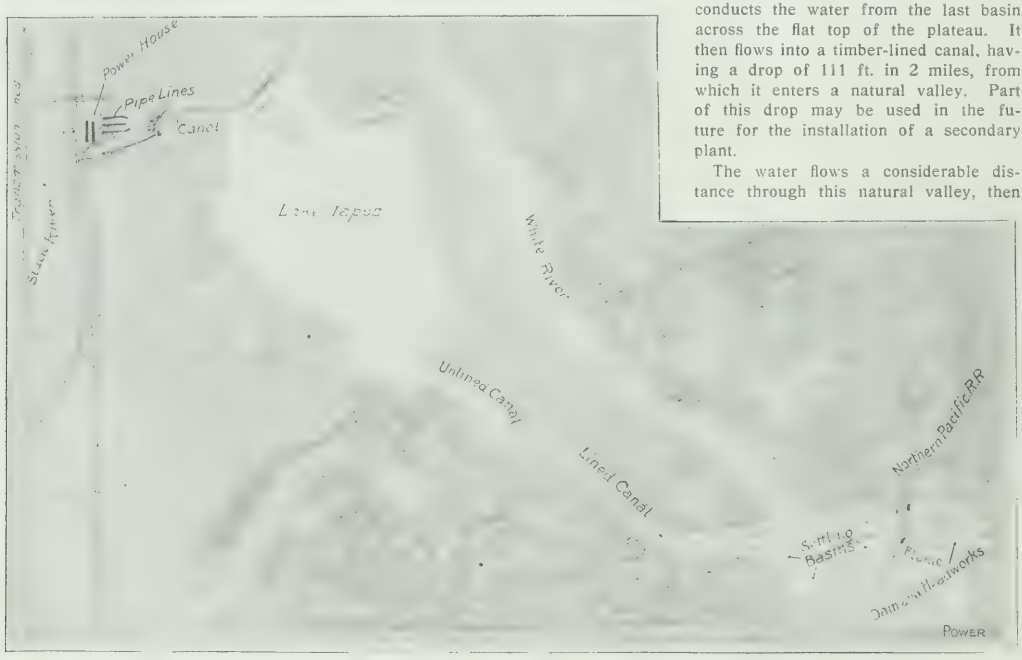


FIG. 1. RELIEF MAP OF WHITE RIVER DEVELOPMENT

age capacity of 2,250,000,000 cu.ft. of water.

The outlet from this reservoir is at the northern end. Here a timber-lined canal, 45 ft. wide and varying in depth to 90 ft., conducts the water a distance of 2500 ft. to the forebay at the entrance to the tunnel which extends through the western ridge plateau. This tunnel is 12 ft. in diameter, 2850 ft. long and concrete lined. The entrance portal is of concrete and has a bell-shaped mouth designed to reduce the entrance head to a minimum. Air shafts in the gate house, behind the gate leading to the tunnel, tend to prevent the production of a vacuum when the gate is closed.

The western end of the tunnel terminates in a circular forebay, located 250 ft. back from the brow of the hill, 75 ft. high, containing 2000 cu.ft. of air under 190 lb. pressure maintained by the static head. This air cushions the water column for each unit independently and permits governing without waste of water. The surge tanks are equipped with pivoted ball floats and valves, allowing the free passage in and out of the tanks but preventing the escape of air into the pipe lines. These tanks may be seen in Fig. 2, both at the brow of the hill and just back of the power house.

Main Turbines

Particular interest centers around the turbines since these are the largest high-head reaction turbines in existence. They were built by the Allis-Chalmers Co. and are each designed to develop 18,000 b.hp. at an effective head of 440 ft. and 360 r.p.m., but are also capable of delivering 20,400 b.hp. at a maximum head of 480 ft. They are designed to withstand the runaway speed at this head without undue strains upon any of the parts.

Two machines are at present installed and space is provided in the same building for two more. They are of the high-pressure Francis type with horizontal shafts. Water is admitted to the spiral casing from below and upon entering the runner is divided into two lines of flow and is discharged from the wheel by two quarter turns to separate draft tubes.

The spiral casing is made in two halves rigidly bolted together and is of cast steel tested to withstand a pressure of 385 lb. per square inch. To reduce the strain upon the casing an annealed cast-steel speed ring is provided. The two inner flanges of this ring carry the speed-gate covers which are bolted to the quarter turns and are bored out to receive the bearings for the pivoted guide vanes.

In order to avoid all obstructions to the free passage of the water at a high velocity and to provide accessibility, all sliding elements are placed outside the casing, employing what is termed the "outside-gate rigging." The guides are of steel with the pivots forged in one piece and project on either side through bronze bushed bearing and packing boxes to the outside of the speed-gate covers. The pivots on the side of the casing opposite the generator carry the levers which are connected to the central shifting ring by individual bronze links and stationary steel pins. The guide vanes are operated from the shifting ring, which has two substantial lugs carrying the pins of the governor connecting-rods. These rods are operated from bell-cranks rigidly interconnected and directly coupled to the main regulating lever and regulating piston.

If any foreign matter should locate between two guide vanes and thus prevent their closing, the governor ordinarily would concentrate its full energy upon the stems, levers and links of these vanes and would tend to deform them. This would call for dimensions of stems which would seriously interfere with the proper design of the guide-vane bodies and unnecessarily increase the friction of the whole gate rigging. The guide-vane stems and levers are, therefore, proportioned to resist only the pressure

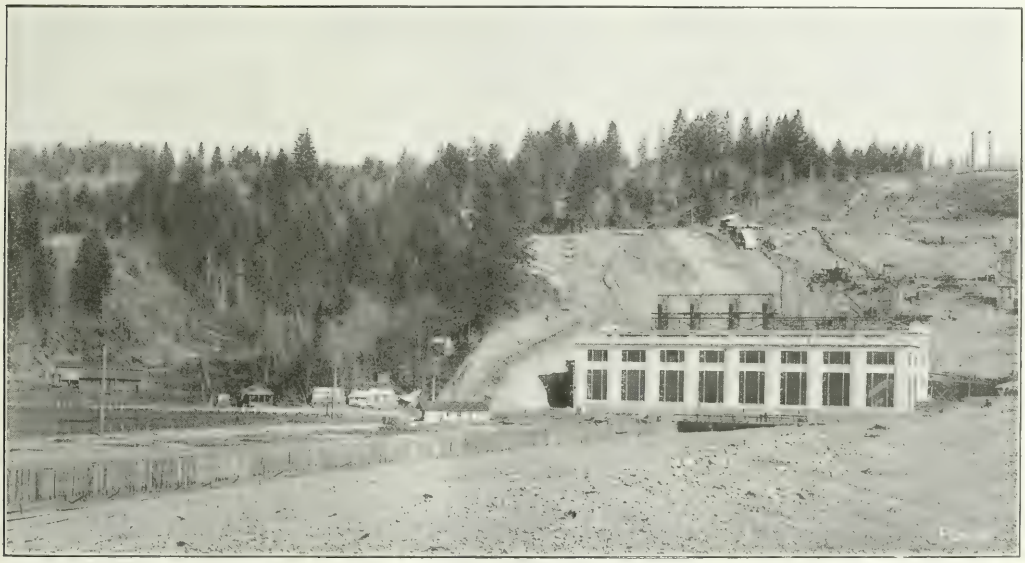


Fig. 2. Power House, Showing Tailrace in Foreground and Surge Tanks in Background

and from here pipe lines convey the water to each turbine in the power house. The length of these pipe lines is 2000 ft., following the contour of the hillside, and the diameter varies from 8 ft. at the upper end to 6½ ft. at the lower. The thickness of the pipes varies from ⅜ to ⅝ in. and the circumferential seams are double-riveted with triple-riveted double-butt straps on the longitudinal seams.

Extensive provision has been made against heavy surges or water-hammer in the pipes. For this purpose an open standpipe 6 ft. in diameter and 85 ft. high is placed at the upper end of each pipe line where it passes over the brow of the hill. The tops of these are 25 ft. above the high-water mark. Furthermore, at the lower end of each pipe line, outside of the power house, are placed two air chambers 7 ft. in diameter and

and strain resulting from the water pressure. To prevent the governor from imposing destructive strains upon the connecting links between the shifting-ring and guide-vane levers, the links are made of such a cross-section as to break at a predetermined stress. The guide vanes are so designed that they have a tendency to close to an opening at which the turbine will operate without load at about normal speed. A breakage of two links can, therefore, not materially affect the speed of the turbine and the two links may, therefore, be exchanged without necessitating a shutdown of the unit.

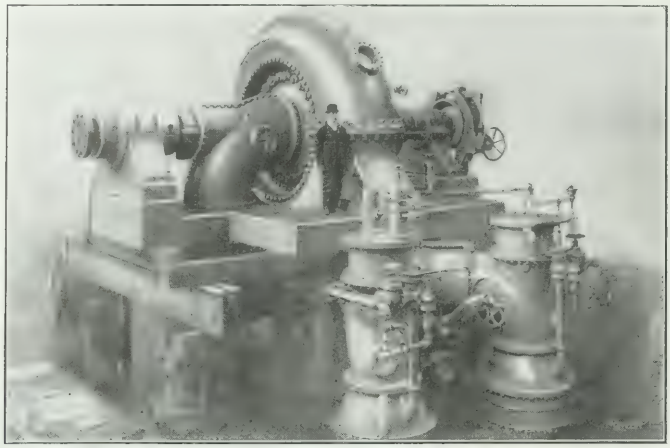


FIG. 3. OUTLET SIDE OF TURBINE, SHOWING PRESSURE REGULATORS

The turbine shaft is of solid openhearth forged steel and rests in ball-and-socket ring-oiling bearings. The driving end in the bearing has a diameter of 16 in., increasing to 32½ in. at the center flange to which the runner is bolted. The opposite bearing serves as a thrust and steady bearing, three substantial thrust collars being forged with the shaft in one piece. The greater part of the thrust, however, is balanced by employing the double-discharge design.

HAND-OPERATED FRICTION BRAKE

The turbine shaft carries the friction brake pulley and the brake yoke is mounted upon an extension of the bedplate. This brake is designed to bring all the revolving elements, at closed turbine gates with the casing under full pressure, to a stop from full speed in 5 min. and the friction surface and pressure are such that under these conditions all the heat produced is safely carried off to prevent excessive heating.

BUTTERFLY VALVES

Since each main turbine has its independent pipe line it was not necessary to provide for a gate valve, because the feeder pipe belonging to one unit can be emptied without interfering with the other unit. However, to provide for shutting off the water supply quickly in case of accident an 84-in. butterfly valve has been provided in each case between the supply pipe and the turbine. The immense size of this high-pressure butterfly valve is best comprehended by considering that a total load of over 2,000,000 lb. rests upon it under the test pressure of 385 lb. per square inch. A bypass is provided for filling the turbine casing and balancing the butterfly valve, and a drain valve is located at the lowest point of the inlet pipe by means of which the whole unit can be completely drained.

GOVERNORS

The governor for each turbine is of the oil-pressure type working in conjunction with the regulating cylinder shown in the illustration, the operating oil being furnished by a central oil-pressure system. The governor stand carries the speed control or flyballs, the floating lever, regulating valve, compensating relay dashpot and synchronizing attachment or switchboard control, and the motion is transmitted on top of the housing to the floating lever. The regulating valve is double acting and hydraulically balanced so that practically no energy is required to raise or lower the valve stem connected to the floating lever. A speed variation of ⅓ of 1 per cent. is sufficient to cause a motion of the gates. The regulating valve is returned into its "dead-beat" position by means of the floating lever operated from the compensating relay dashpot. The dashpot receives its motion from the relay connection of the regulating piston.

In order to limit the maximum gate opening of the turbine, when regulated automatically, a load-limiting device is provided so that the governor is prevented from opening the turbine gates beyond a desired amount. To enable

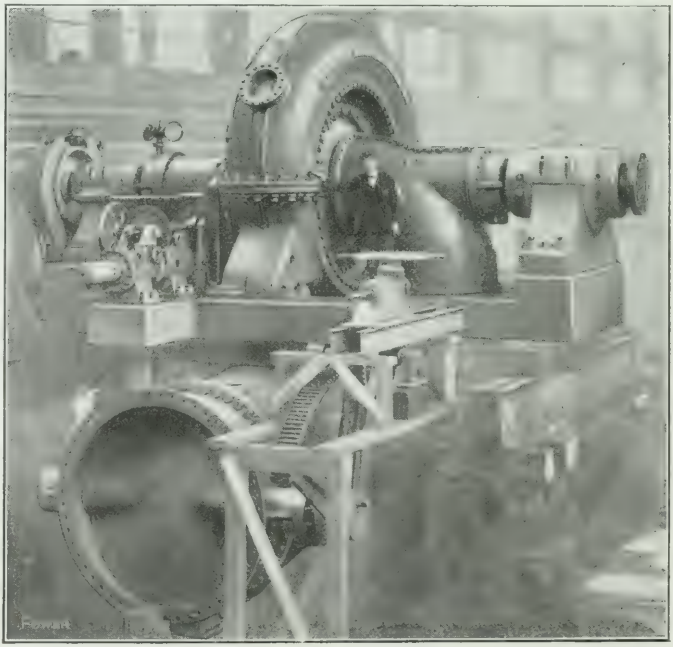


FIG. 4. INLET SIDE OF TURBINE, SHOWING BUTTERFLY VALVE

inspection or repairs to any part of the governor without shutting down the whole unit an independent hand-regulating device is provided. This is placed above the regulating cylinder and so connected with the extended regulating lever that it can be conveniently thrown in or out of operation.

Pressure Regulators and Bursting Plates

In order to protect the pipe line against serious pressure rises and to assist the governor in obtaining close speed regulation, pressure regulators are provided; these are both governor and pressure operated. Furthermore, to protect the pipe line in case of failure of either of these devices, a bursting plate is provided.

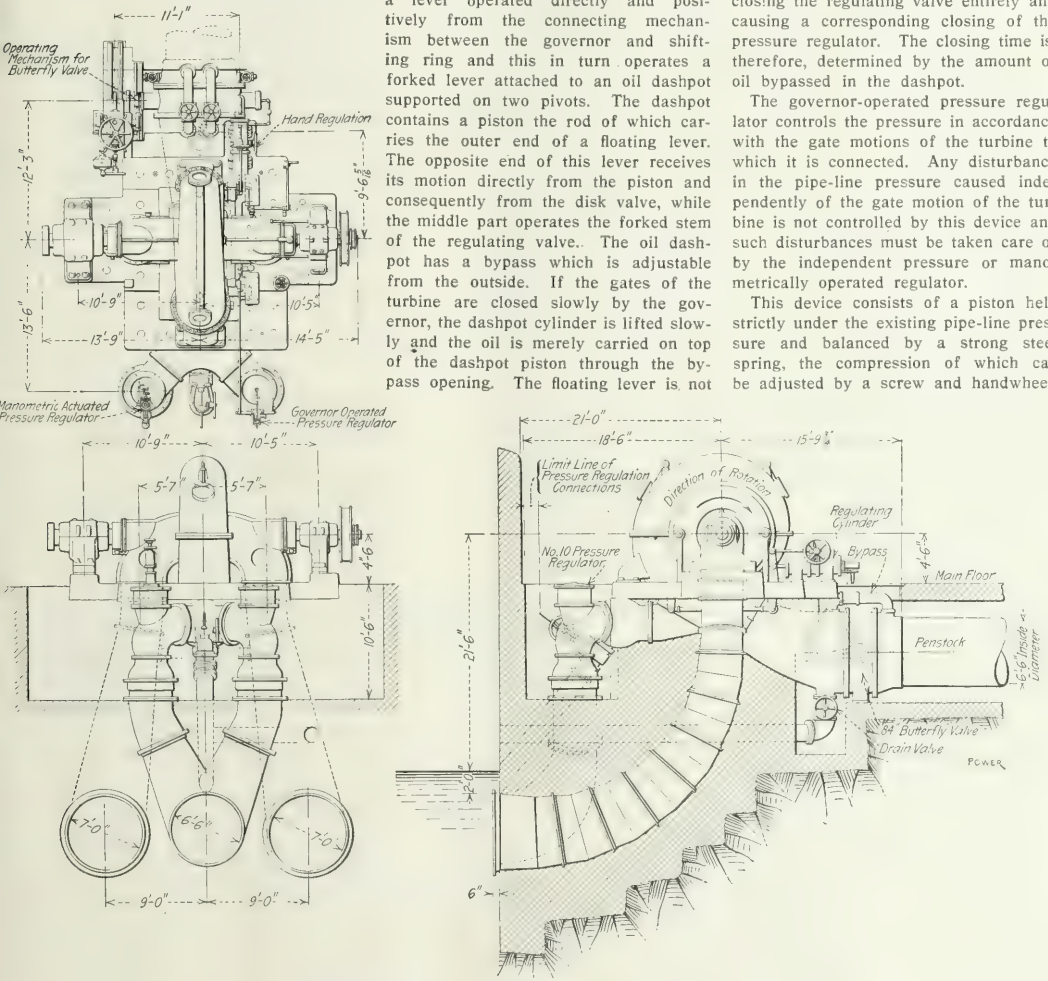
A Y-connection is attached to the bottom of the spiral casing, one branch leading to the governor-operated pressure regulator, the other to the pressure-operated regulator and the neck of the Y-pipe connects to a hand-operated gate valve which at its lower end carries the bursting plate and its discharge pipe. The discharge pipe from the bursting plate empties independently into the tail-race pit.

The principle and arrangement of these two pressure regulators is shown in Figs. 3 and 8. The governor-actuated device consists of a shaft carrying a lever operated directly and positively from the connecting mechanism between the governor and shifting ring and this in turn operates a forked lever attached to an oil dashpot supported on two pivots. The dashpot contains a piston the rod of which carries the outer end of a floating lever. The opposite end of this lever receives its motion directly from the piston and consequently from the disk valve, while the middle part operates the forked stem of the regulating valve. The oil dashpot has a bypass which is adjustable from the outside. If the gates of the turbine are closed slowly by the governor, the dashpot cylinder is lifted slowly and the oil is merely carried on top of the dashpot piston through the bypass opening. The floating lever is not operated, and consequently the pressure regulator is not opened.

If, however, the gate motion of the turbine is quick, due to a sudden reduction of load, the oil is not bypassed quickly enough, an over-pressure is created below the dashpot piston, thus raising the floating lever and causing a lift of the regulating-valve piston. The pressure is reduced below the piston and the valve opens; at the same time, however, the opposite end of the floating lever is lowered simultaneously with the opening of the disk valve and the regulating-valve piston is brought back toward its closed position, holding the disk valve in a balanced position. Due to the bypassing of the oil in the dashpot, the piston is allowed to move slowly in a downward direction, thus closing the regulating valve entirely and causing a corresponding closing of the pressure regulator. The closing time is, therefore, determined by the amount of oil bypassed in the dashpot.

The governor-operated pressure regulator controls the pressure in accordance with the gate motions of the turbine to which it is connected. Any disturbance in the pipe-line pressure caused independently of the gate motion of the turbine is not controlled by this device and such disturbances must be taken care of by the independent pressure or manometrically operated regulator.

This device consists of a piston held strictly under the existing pipe-line pressure and balanced by a strong steel spring, the compression of which can be adjusted by a screw and handwheel. This piston operates a lever which at its outer end carries the stem of the regulating valve. Any pressure rise will cause a compression of the spring, imparting an upward motion of the piston and the regulating-valve piston.



Figs. 5, 6 and 7. Plan View, End and Side Elevations of Turbine, Showing Governing Devices

To prevent the sand from interfering with the sensitiveness of the manometric device, the water pressure is not directly admitted to the cylinder but is carried into a pressure tank completely filled with oil so that this oil under pressure transmits any fluctuation to the manometric piston and spring and, due to its lubricating qualities, keeps it in perfect condition and sensitiveness.

Exciter Turbines

Each of the two exciter turbines is designed to develop 500 b.hp. at 420 ft. effective head when running at a normal speed of 400 r.p.m. and to safely withstand a runaway speed of 800 r.p.m. The wheels are of the impulse type with hand-adjustable needle-valve regulation and governor-operated deflecting hoods.

The deflecting hood consists of a forked lever hinged below the nozzle and carrying a removable knife-edged blade. This blade cuts into the jet from underneath in such a manner that the entrance edge is parallel to the axis of the jet, so that the upper, undeflected portion of the jet

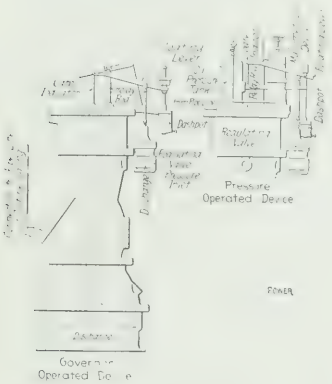


Fig 8. Pressure Regulator

impinges upon the buckets practically undisturbed, while the lower portion of the jet is deflected into the bottom of the wheel pit where it strikes a removable steel plate lining. The shaft of the deflecting hood projects through the wheel housing above the power-house floor, so that it can be directly connected to the regulating shaft of the governor.

The governor is of the self-contained Allis-Chalmers oil type, and is not connected to the central oil-pressure system but furnishes its own oil pressure for regulation. This enables independent operation of the exciter units so that the field can be held on the generators irrespective of the conditions of the governors of the main unit.

Oil Pressure System

For supplying oil under pressure three rotary gear pumps are at present installed, each of a normal capacity of 90 gal. per minute against a pressure of 400 lb. per square inch. Two are directly coupled to a 65-hp. induction motor, and the third is coupled to such a motor on one end and to an independent small impulse wheel of corresponding power on the other side. The pumps are of the double-stage type, the low-pressure stage picking up the oil from the receiver tank and discharging it at about 200 lb. pressure directly into the suction side of the high-pressure stage, which raises the pressure from 200 to 400 lb. per square inch and discharges into the pressure main.

Two independent receiver tanks of steel plate are provided which are partly set into the basement floor, so that all oil can discharge into them by gravity. Provision is made for liberal contact of the oil with air; the oil returning from the governors or safety valves discharges over a screen whereby it frees itself of air and all impurities as well as heat. The two receivers are interconnected by a pipe with proper valves so that the oil can be transferred from one tank to the other or the levels kept uniform.

A concrete pier between the two receivers carries the two main pressure tanks, which are of riveted steel plate and tested to 600 lb. per square inch and have a capacity of about 250 gal. each. A safety valve of the spring type is attached to each pressure tank and may be set to any desired pressure between 300 and 400 lb. per square inch; it discharges all excess oil directly into the receiver.

One main pressure pipe and one main return pipe carry the oil from the pressure tanks to the main governors and from there back to the receiver tanks. These pipes are of 4½ in. inside diameter and are made of seamless tubing annealed and bent with radii of at least 12 in. so that the flow of oil is not subject to abrupt changes in direction.

Two auxiliary pressure tanks are connected to the ends of the supply pipe in order to prevent a serious drop of pressure due to the acceleration of the oil in the long supply pipe between the pressure tanks and the governor. The two main and the two auxiliary pressure tanks are interconnected by an air pipe and to a motor-driven air compressor located in the basement. By means of this piping the air levels can be equalized between the various tanks or new air quickly supplied.

Electrical Equipment

The main generators are 6600-volt, three-phase machines, coupled direct to the turbines and rated at 10,000 kw. each. These were furnished by the General Electric Co. and under test showed an efficiency of 96.8 per cent. The exciters are each of 225 kw. capacity, furnishing direct current at 240 volts and are direct-connected to the impulse wheels. Provision has been made in extending their base plates for driving them by induction motors if this should be desired at any time.

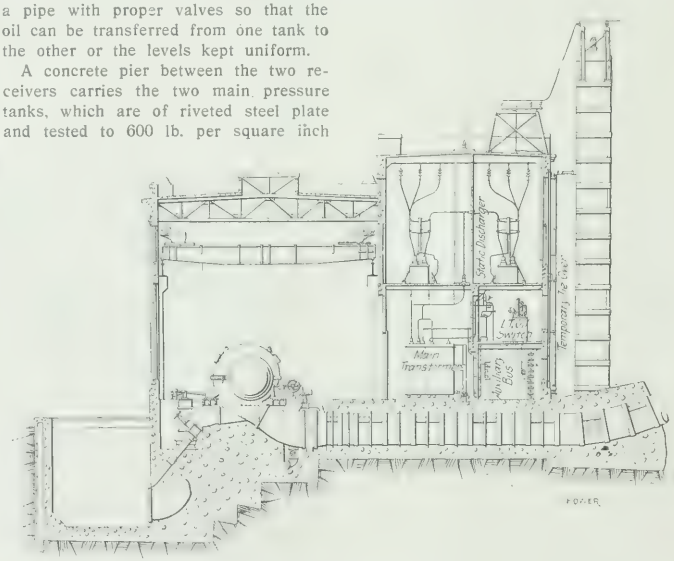


Fig. 9. Section through Power House

Water-cooled, oil-insulated transformers each of 3333 kw. capacity, step up the voltage from 6600 to 55,000. Three auxiliary transformers of 200 kw. each step down the voltage to 2300 for local power and lighting. In addition there are six 75-kw. transformers which step down to 220 and 110 volts. The usual form of high-tension switching apparatus and remote control is employed.

The engineering and construction work was carried on under the supervision of Stone & Webster, of Boston.

Kerchove and Uniflow Steam Engines*

Dr. Doederlein, of the Saechsische Maschinenfabrik, builders of the Kerchove engine, makes some comparisons between this type and the Stumpf uniflow engine, which show up the former to advantage.

*Translated and abstracted by William F. Monaghan from a contribution by Dr. Ing. Doederlein to Zeitschrift des Vereines deutscher Ingenieure of Oct. 7, 1911.

In 1893, Dr. Schröter, professor in the University of Munich, made a report† on investigations of a Kerchove compound engine, the surprisingly favorable results of which astonished the whole technical world. These tests were made on a single-crank compound condensing engine of 217 i.hp. at the works of the Société Anonyme van den Kerchove in Ghent with different loads and degrees of superheat.

The steam-consumption figures determined from a test on a Kerchove engine in 1902 with constant load and different degrees of superheat are shown in Fig. 1. The middle curve shows the steam consumption D_i in pounds per indicated horsepower per hour with increasing superheat. The bottom curve D_o gives the steam consumption of a "no-loss" engine, corresponding to complete adiabatic expansion of the steam from initial conditions before entrance into either the cylinder or the jacket to its terminal condition at exhaust. The top curve was obtained from the ratio corresponding with the reciprocal value of the indicated efficiency. For present use this ratio $\frac{D_i}{D_o}$ has been designated as "loss factor." The introduction of this new expression would prevent any further confounding with the ambiguous notation of the reciprocal value, variously designated as thermodynamic efficiency, indicated efficiency, efficiency ratio (Güteverhältnis), or cylinder efficiency (Gütegrad), which are referred to the pressure of the exhaust outside of the release valve.

If for a given design of engine the loss-factor curve is known, the steam consumption for any desired operative condition is easily determined, in that D_o is calculated with the help of the Mollier diagram and the result multiplied by the appropriate loss-factor.

If the series of tests represented by Fig. 1 is noteworthy in its low steam consumption, then the unusual course of the curve of steam consumption in Fig. 2 is especially prominent. Compared to such curves from other steam engines which with decreasing loads rise rather rapidly, that of the Kerchove engine drops with loads decreasing from normal to about half. The steam-consumption curve for the Kerchove engine runs almost parallel to that of the ideal engine, the falling off of the latter curve being incident to improvement of the vacuum through the lesser demand on the condenser. On the other hand, the loss-factor curve plainly shows that the internal losses of the engine decreases to nearly 70 per cent. of the normal load; thereafter slowly increasing.

For these qualities, so valuable for the operating conditions of varying load and continued underload, the Kerchove engine is indebted to its generally efficient design, but mainly to the piston valve which renders possible the opening and closing of the steam passages, even at short cutoffs, at the highest speed, preventing thereby throttling of the inflowing steam. Such a high degree of economy with a reciprocating steam engine had not before been attained nor considered possible; hence the Schröter investigations were at the time regarded as inapplicable laboratory tests, and their reliability was strongly doubted. However, the numerous tests made on the Kerchove engines turned out by the Sächsische Maschinenfabrik proved that the steam-consumption figures of the Schröter tests were not only equaled by the present-day Kerchove engines in practical, continued operation but, in many cases, were lowered.

Recently there appeared on the market the so called "uniflow" engine which under the Stumpf design is being turned out by first-class engine works and, at least in economy, is found in favorable competition with the compound engine. It is therefore interesting to compare the economies of the uniflow and the Kerchove compound engines. Here again, however, only such engines should be selected for testing as have a close agreement of exhaust pressures and depart not too widely from those of the Kerchove engines.

Although the steam-consumption figures of the compared uniflow engines vary but slightly from those of the Kerchove engines, the comparison having been obscured by the different conditions of operation, such as very high pressures and superheat and excellent vacuum, nevertheless on comparing their loss factors the distinctive economies of uniflow and Kerchove engines become plainly evident.

In wise recognition of the thermal advantages of the Kerchove engine, such as inclusion of the valves within the cylinder heads with its resultant minimum clearances and surfaces and the ample jacketing of the heads with live steam, the uniflow engine adopted them, and therefore must not be compared with a compound engine of ordinary design solely on a basis of its unidirection of steam flow.

In technical circles the conviction is constantly gaining ground that the results from the uniflow engine are due to this design and not to the doubtful thermal advantages of the uniflow direction of the steam. The chief advantage ascribed to it is the more favorable cylinder temperature at the end of the stroke. This, however, on closer examination of the quality of the steam, seems very unlikely inasmuch as in a

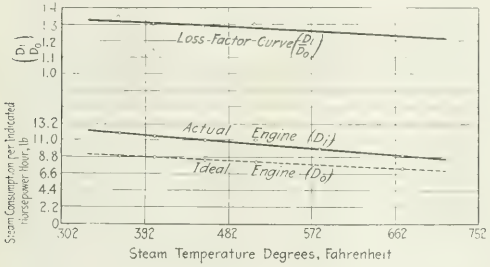


FIG. 1. STEAM CONSUMPTION AND LOSS FACTOR CURVES PLOTTED AGAINST TEMPERATURE

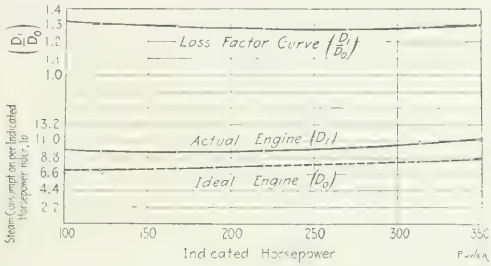


FIG. 2. STEAM CONSUMPTION AND LOSS FACTOR CURVES PLOTTED AGAINST HORSEPOWER

†Zeitschrift des Vereines deutscher Ingenieure for 1893, page 1281.

condensing engine the steam at the end of the expansion is fairly wet, so that at the jacketed head there should be, at most, a drying but no material superheating.

Proportional to its pressure and throughout the cylinder the steam has, then, a temperature of vaporization of from 122 to 140 deg. F., so that also in the uniflow engine the heated wall surfaces are in contact with cooled steam. Of course, in the uniflow engine the cylinder head is less exposed to the outflowing steam; in place of which, however, even if for lesser time, are the unheated piston surfaces, the cooling of which can work still greater thermal disadvantage than can that of the head surfaces. Hence in the uniflow engine as compared with the "reverse flow"* engine the cylinder heads and pistons have merely exchanged places, and in view of this the uniflow engine has no recognizable advantage.

measure of such adjustment, the duration of the exhaust being also a factor; and this in the uniflow engine extends over, at most, 10 per cent. of the stroke, while from 80 to 90 per cent. is provided in the reverse-flow engine.

From all tests made so far, the unusually low vacuums necessary with the uniflow engine for minimizing the compression have reduced the steam consumption but relatively little; for with an economical cutoff expansion cannot be sufficiently utilized in a reciprocating engine, a condition in no way changed by the uniflow design.

Although from observations of Stumpf the uniflow almost entirely prevents cylinder condensation, he has of late added jacketing and claims to have thereby obtained material improvements. This seems a counterproof against the stated thermal advantages of the uniflow design.

In engines with a good vacuum and tight valves the compression remains within allowable limits; under favorable conditions, however, it easily exceeds the initial pressure, and with free exhaust the clearances must be materially increased so that the uniflow engine with atmospheric exhaust operates with less economy than a single-cylinder reverse-flow engine.

Accordingly, the only undoubted advantage of the uniflow engine came into existence through the discontinuance of the exhaust valve and its clearance; an advantage inversely, of course, as the tightness of the exhaust valve and the degree of superheat of the incoming steam. The unusual cylinder and piston lengths of the uniflow engine are a disadvantage in comparison with the reverse-flow engine, for the temperature differences between the middle and both ends of the cylinder are conducive to unequal expansion and its resultant operating difficulties.

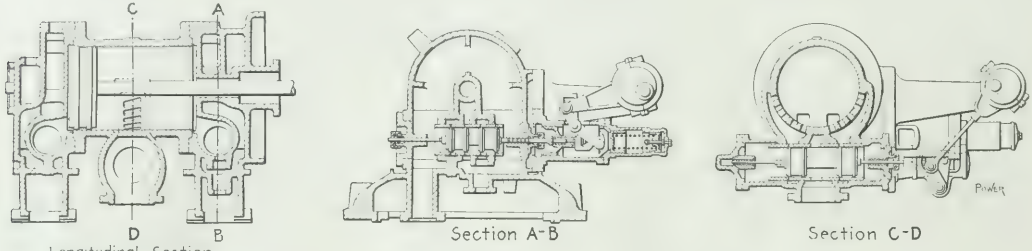


FIG. 3. KERCHOVE ENGINE WITH PISTON VALVES FOR INLET AND EXHAUST

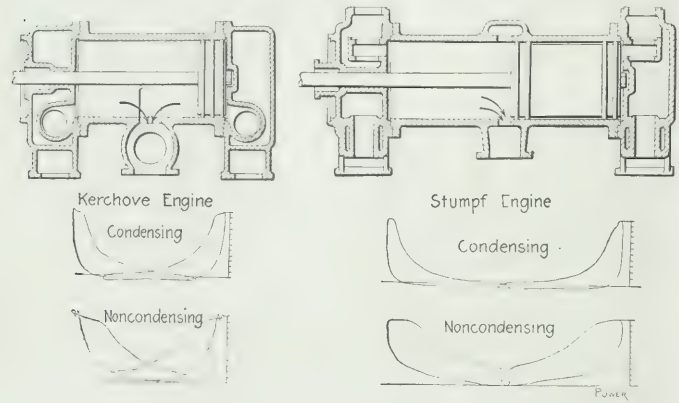


FIG. 4. KERCHOVE AND STUMPF ENGINE CYLINDERS WITH THEIR RESPECTIVE INDICATOR DIAGRAMS

A further preference ascribed to the uniflow engine is the relatively large cross-section of the outlet ports, resulting in a better adjustment of pressure between the cylinder and the condenser. Cross-section alone, however, is not a

*The term "reverse flow" is used to designate the steam path in the cylinder of an ordinary reciprocating engine in contrast to that designated by the term "uniflow."

In order to utilize the advantages of the uniflow engine and avoid its disadvantages, the Sächsische Maschinenfabrik applied in 1909 for a patent on a new engine design, shown in Fig. 3. This shortened uniflow engine has the exhaust port not at the end of the stroke but approximately at the middle, in consequence of which a release valve is obviously required to close the port during expansion. Fig. 4 plainly shows the different cylinder and piston lengths of both designs; and, as is evident from the diagrams, the temperature and pressure of the expanding steam are already so low at release that there is neither a noticeable pressure drop nor condensation loss resulting from the increase of detrimental volume due to the use of the valve. For high speeds the engine is built with a shaft governor and positive valve-gear and piston valves are used; those for admission being located horizontally in the bottoms of the cylinder heads which are jacketed by the inflowing steam. The Sächsische Maschinenfabrik has had such a uniflow engine in operation on its testing floor for some time, and the principal results determined from duty tests are as follows:

Initial steam pressure, pounds per square inch	152
Steam temperature at the throttle, deg. F.	498
Back pressure in the cylinder, pounds per square inch absolute	2
Heat consumption, B.t.u. per lb. of steam	269.15
Steam consumption, pounds per i.hp.-hour	11.48
Heat consumption for 592 deg. F., B.t.u. per pound	335.47
Steam consumption, referred to 572 deg. F.	10.93

The value of the loss-factor shows nearly the same economy for this shortened uniflow engine as for the Stumpf design.

An important consideration peculiar to this engine is the three-part design of the steam cylinder made up of the cylinder proper and the two valve-containing cylinder heads. Fig. 5 shows such a cylinder with a steam jacket for which the live steam enters at its bottom midlength and flows into and out of the heads. Particularly noteworthy is the absence of all attachments and ribs in the cylinder proper, avoiding harmful stresses under high temperatures. Fig. 6 shows an inner view of a head. In Fig. 7 will be noted the close proximity of the valves to the piston, also the small clearances, the axial inflow of the steam and the ample jacketing of the cylinder heads by the entering live steam.

A second and equally important means for the attainment of high economy, particularly with underloading and with continued operation, is the piston valve as a cutoff and regulating device.

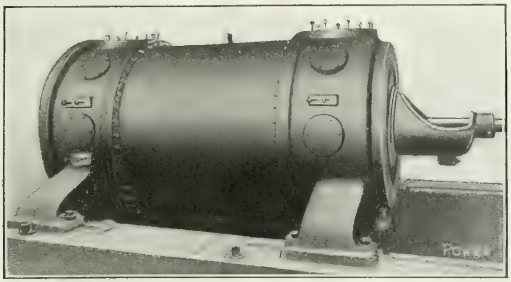


FIG. 5. STEAM JACKETED CYLINDER

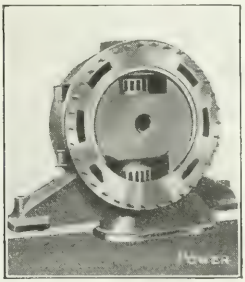


FIG. 6. INTERIOR VIEW OF CYLINDER HEAD

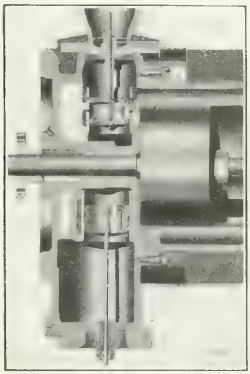


FIG. 7. VALVES AND PISTON

of both latches there is an automatic and almost perfect equalization of the cutoff at all loads for both ends of the cylinder; and through a suitable arrangement of the path of the roller there is, further, a very favorable apportionment of the cutoff throughout the whole travel of the governor.

The low-pressure cylinder is usually built with a positive gear, but if steam is to be taken from a receiver it is provided with a releasing gear like that of the high-pressure cylinder. A pressure regulator is placed on the control shaft of the high-pressure cylinder while a centrifugal governor determines the cutoff for the low-pressure cylinder. The pressure regulator is set below the pressure in the receiver and lengthens or shortens the cutoff in the high-pressure cylinder as the demand on the receiver is respectively increased or diminished.

The competitive introduction of the Kerchove engine in Germany was opposed mainly by the pretended difficulty of access to the interior of the cylinder. Experience, however, has very much lessened this objection, especially as by means of the simple contrivance illustrated in Fig. 8 the cylinder heads can be moved back. The cylinder rests on a cast-iron frame having planed slots which accurately guide the heads in their withdrawal. This can be accomplished, even with the heaviest engines, by one man with the aid of the pinion and ratchet bar attached to the head supporting lugs. The unity of that part of the valve-gearing integral with the head is not disturbed, as all that is necessary is the removal of two bolts to free it from the eccentric located on the control shaft running alongside of the cylinder.

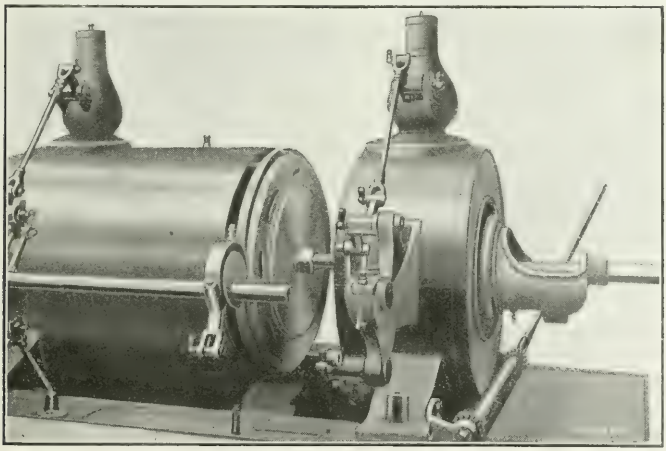


FIG. 8. METHOD OF REMOVING CYLINDER HEADS

The high-pressure cylinder is fitted with a releasing gear actuated by a single eccentric for admission and release. Through the different lengths of the roller levers which regulate the cutoff and the correspondingly different bends

Lunkenheimer Cast Steel Valves

Superheat and high steam pressures have created a demand for valves of great strength and durability, and anticipating the requirements the Lunkenheimer Co., Cincinnati, Ohio, has designed a complete line of globe, angle, cross, gate, check, nonreturn boiler stop valves, etc., made of cast steel for such use.

With the exception of the largest sizes, these valves are made of crucible steel and are annealed to relieve internal stresses. It is claimed that these valves contain less than 0.05 per cent. of either phosphorus or sulphur. Their tensile strength is about 80,000 lb. per square inch, with a safe elastic limit and excellent elongation.

For various pressures and degrees of superheat and to meet the requirements of engineers who differ as to the material used, these valves are made in two combinations of material as regards the trimmings.

The March issue of *The Engineers' List* contains a record of 26 buildings in New York City which have abandoned Edison service and are now operating private plants, having found the latter more economical.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

The engineer has a thrilling experience when a piece of gasket prevents closing the throttle while men are being hoisted in the cage.

A loose pin put the reversing gear out of operation on another occasion.

Ignorance in adjusting the steam valve pressure plate caused a serious accident and loss of life.

To the man who is unaccustomed to the methods employed in coal mining there is much of interest and instruction. Consequently I was anxious to see more of the mines, but it was several days before Hunter and myself again visited them, although we met at dinner each night.

A perusal of the daily papers shows that coal mining is a far from safe occupation, for scarcely a day passes but that some poor fellow meets with an accident, and doubtless many more occur, an account of which is never published.

One evening a news item related how a headman at a nearby colliery had fallen 900 ft. to the bottom of a shaft. I read the item to Hunter, who replied:

"That fall never hurt the man, for he had lost consciousness before he struck the bottom. He didn't suffer half as much as I once did while hoisting a cage carrying miners and could not get the throttle valve shut.

A Piece of Gasket

"Most throttle valves are arranged midway between the two cylinders, either on the overhead pipe, or in a pit between the engines. Ordinary rubber gaskets are used in making up the joints, and the plant I was running at that time was no exception to the rule.

"The engine had been working all right during the day, and there was no sign of trouble until the cage and the men were nearing the top. When I closed the throttle I found to my horror that I could not shut the steam off from the engine.

"There was but one thing to do—control the engine by means of the reverse lever. The engine was reversed, and as soon as it came to a stop the cage began to descend, and before it reached the bottom of the shaft it was again reversed. The men were thus hoisted up and down until help was obtained and the steam shut off from the engine by means of a separate valve in the steam line. When the valve was examined a piece of sheet packing was found between the valve disk and the seat which allowed enough steam to pass through to run the engines at a fair speed."

"Where did the piece of rubber gasket come from?" I inquired with interest.

"I never found out," said Hunter, "but I suppose it was from some loose end that had never been cut off when the gasket was put in."

I smoked a while in silence, wondering why Hunter had not stopped the engine instead of lowering and hoisting the cage until the steam supply was cut off. I finally put it to him.

Open Eccentric Rods

"I couldn't stop," he answered, "because the eccentric rods on that particular engine were arranged open; that is, with the link and reversing gear in mid-position, the eccentric rods were not crossed and consequently the valve on one cylinder was open or had lead. Had the piston rods been arranged to cross when the link was in mid-position, there would not have been lead on the cylinder and the engine would have stopped without any trouble."

"As I understand the case," I said, "with the eccentric rods crossed, the steam ports of both cylinders are closed when the link is in mid-position, and the steam cannot enter either of the cylinders."

"That is it exactly, and why more engines are not arranged that way is a question I cannot answer."

"These miners must have said a few things," I remarked.

Pin Worked Loose

"Not so much as some others did at another time," was the reply. "I was hoisting the men slowly, as was my custom, and if the cage had been coming up at the rate of speed with which coal is hoisted those men would have required a parachute with which to make a landing.

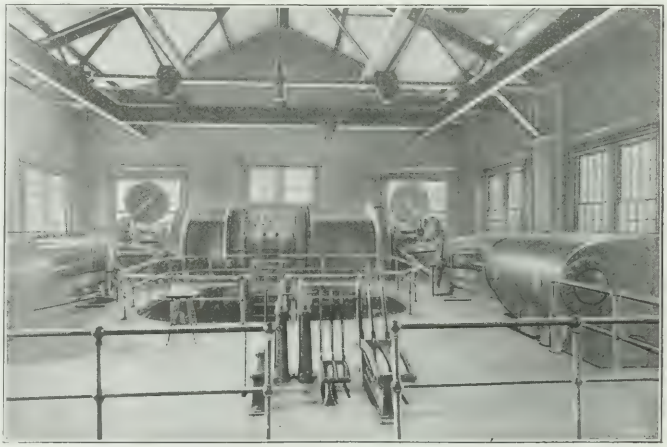
"You have noticed that the link motion is actuated by an auxiliary cylinder, the link being lifted by an arm which is connected to a short lever by a pin passing through both.

"For some reason—probably carelessness as much as anything else—I neglected to examine my engines that morning and, of course, that was the time something had to happen. Accidents come as quickly with hoisting engines as with any other kind of machinery. In this instance the engines had been operating all right during the day, and it was not until the men started to come up that anything went wrong. Four loads of men had been hoisted, and the fifth was on the way when I began to ease up on the speed and found that the engines would not plug or reverse.

"It occurred to me that the trouble was in the reverse gear, and, as there was nothing else to do, I shut off the steam, applied the brakes, and stopped the engines with the cage about a foot from the top of the headwork. I found out later that the pin in the lifting arm had worked out of place."

"I guess those miners got a scare coming up in that manner," I said.

"They did, and so did I, but a miss is as good as a mile. When the men found out what was the matter and how I had stopped they thought I was about the best fellow around the mine."



There Are Many Levers to Handle, Dials to Watch and Signals to Obey

Guarding against Accident

"I have heard that most accidents occur from overwinding or hoisting the cage when it is at the top of the shaft. Why is that?"

"Because there are a good many levers to handle, dials to watch and signals to obey. One good way to avoid accidents of that character is to watch the winding rope as well as the indicator dial. Another preventive against accidents, in case there is doubt regarding signals, is to find out what signals were given before starting the engine. An engineer may have his attention called to some trouble about the plant; perhaps a crank-pin has been bothering him with heating and his mind is on that; he may think the signal to hoist has been given, and, without verifying the signal, start the engine and thus may cause an accident. If the time is taken to find out from both the footmen and the headmen what the last signals were, mistakes in signals are eliminated."

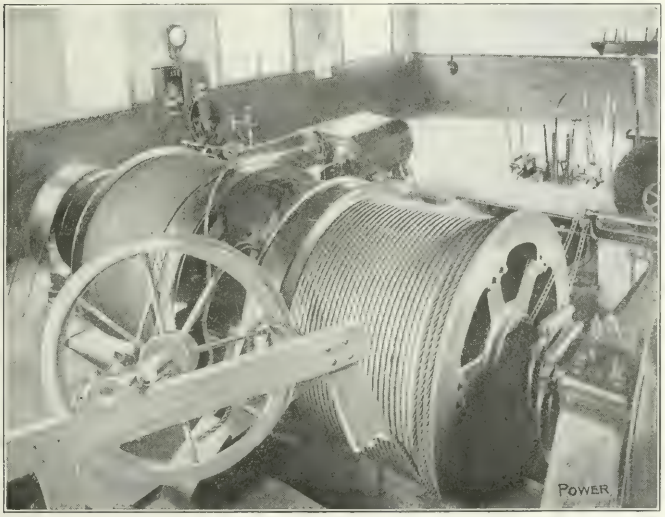
Carelessness

"Men get careless, I suppose."

"They do, but sometimes ignorance has much to do with engine troubles. For instance, the side valve of many hoisting engines is fitted with a pressure plate, the purpose of which is to prevent the valve from slapping when the engine is running without steam.

"One day I decided that the plate was too loose and required setting up, and so before going home that night I adjusted it. The next morning before taking on men I started to run the cage up and down, as was my practice in order to make sure that everything was all right. I threw my reversing-gear lever over and happened to look at the link of the valve-gear at the same time. To my surprise, the link did not move, although the lever had been thrown its full travel.

"I tried it again and found that, although the rods controlling the steam valve on the auxiliary cylinder moved the valve of that cylinder, the piston did not move and, of course, the links which the piston operated failed to move. An examination of the cylinder failed to disclose anything out of order, and then I thought of the adjustment I had made of the pressure plate the night before, and that was where the trouble lay.



Fragments of the Cage and Head Works Were Drawn Into the Engine Room

"After taking off the steam chest, I turned to do something else, and it was some time before I got to work on the pressure plate, so that it had cooled considerably before the adjustment was made. I adjusted it rather closely anyway and did not make allowance for the expansion of the valve when it was hot. The result was that when steam was admitted to the auxiliary cylinder at the reduced pressure used there was not enough pressure back of the piston to operate the valve and valve-gear, because when steam was admitted to the cylinder of the main engine the valve expanded between the valve seat and the pressure plate, and the friction was so great that the auxiliary cylinder could not move the valve. When the pressure plate had been loosened, the valve-gear operated as it should."

"Rather a close call. I will venture to say you never made another similar mistake."

Steam Valve Stuck

"I never made the same mistake again, but a friend of mine did, even after I had told him of my experience; in fact, he did the same thing. He had for years been in the habit of lowering men without testing his engine. The morning after he had adjusted the pressure plate of his engine he loaded the cage with men, and throwing his reversing lever in a position to lower he opened the throttle and sent the cage up to the top of the headframe, killing half a dozen men and injuring as many more. Before the engine was stopped, fragments of the cage and headworks had been drawn into the engine room through the side of the building and lodged under the winding drum. It was another instance of the auxiliary cylinder failing to operate the main valve-gear.

"That engineer made another mistake, one that is made by many others; that is, he opened the throttle valve too wide and got his engine going too fast before he had time to find out that it was going in the wrong direction."

By this time the waiter was standing on pins and needles waiting for a chance to clear up his table, and so we adjourned, Hunter to keep an appointment with a friend, while I went to a moving-picture show.

Reversible Steam Turbine

Another step has been taken in the perfection of the turbine, says the London *Standard*. Experiments and demonstrations have been made by Wainwright Brown on a reversible steam-turbine model 30 ft. long and about 18 ft. in breadth. It is reversed from full speed in one direction to full speed in another in a few seconds.

The reversing is effected by synchronized disks rotated by screw spindles extending outside the turbine casing which are made to open or close by nozzles which give the steam a left or right direction upon the blades.

Designs are now under preparation for the construction of a 2000-hp. machine on the new principle. It is the purpose of the inventor to adapt all sizes for the use of gas in place of steam.

Several large steamship companies have the new invention under consideration as a means whereby to increase the speed of their fast liners.

On Jan. 4, the load on the Chicago Commonwealth Edison Co.'s stations was 201,630 kw. Ten years ago it had passed the 20,000-kw. mark. The first figures probably reach the largest output of any electrical-supply system in the world.

Economy Factors in Power Plants*

By Charles Brossmann

A consideration of the various items which, apparently small in themselves, when taken together will seriously affect the economy of a plant if they are neglected.

*From a paper delivered before the Indiana Engineering Society.

Economy in the production of power in many small- and medium-sized plants is not given the same thought as in the larger plants. This is not always due to the equipment not being high grade, but rather to numerous losses which can mainly be attributed to inattention or lack of knowledge of the small details which, considered as a whole, are important. Very few have any reliable check on what they are producing and the cost thereof. Coal is purchased from the lowest bidder and perhaps a rough check is made as to the amount of water pumped, but it is seldom known whether each part of the plant is doing its share in an efficient manner.

Considering first the boiler room: with a certain grade of fuel and under certain conditions, a given number of pounds of water per pound of coal should be evaporated. To keep track of this the coal must be weighed and the water measured. The coal is best weighed between the bins and the boilers for in this way the amount can always be found without referring to that in the bin. The meter for measuring the water should be installed between the feed pump and the boiler in order that all water entering the boiler may be accounted for.

With means for weighing both the water and the coal, the evaporation of a certain coal will be known under proper conditions; that is, clean boilers and flues, proper draft, etc. If the evaporation should drop, say, from 8 lb. of water per pound of coal to 7 lb. with the same fuel, it would at once be apparent that something was wrong—either the coal was not up to the standard or the boilers were scaled or the tubes covered with soot.

Few boilers are operated with a minimum amount of scale, and with tubes clean both internally and externally. The accumulation of ⅛ in. of scale will make a difference of 15 to 18 per cent. in the evaporation and the accumulation of soot in return-tubular boilers with the corresponding loss due to drop in draft and insulation loss will add still further to this figure. The chart, Fig. 1, shows the approximate loss due to scale, based upon 320 days' operation per year with coal at different prices. For example: Suppose coal costs $2.50 per ton and six tons are used per day where the scale on the tubes is ⅛ in. thick; the resulting loss will be $1000 per year. The loss due to uncovered steam piping is shown by the chart in Fig. 2. Suppose conditions under which there is 200 ft. of 6-in. pipe and the coal costs $1.85 per ton. Tracing on the chart as indicated by the dotted lines, the loss will be $180 per year. If magnesia lagging is used the saving will be

$$0.85 \times 180 = \$153$$

A very important factor that has much to do with the economy is the cleanliness and order of the boiler room. One usually finds poor economy in a dingy, dirty boiler plant. Inside cleanliness is more important, but the order outside is often the index of inside conditions.

There is quite a loss in many plants due to the boiler settings being cracked. All cracks admitting air should be repointed and small hair cracks can have a coat of thin paint or whitewash. All cracks around the iron work and in the breeching should be also stopped up.

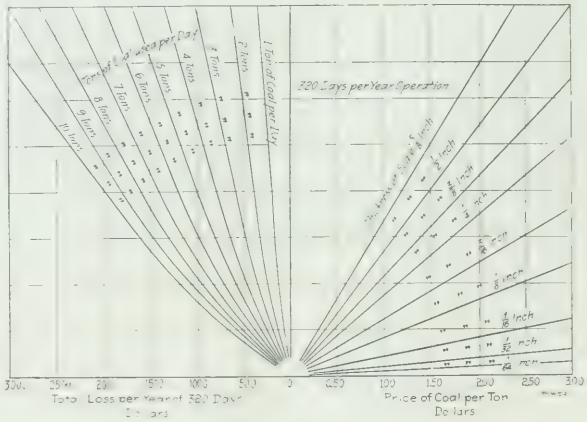


FIG. 1. LOSS DUE TO BOILER SCALE

FEED-WATER HEATERS

In a noncondensing plant the main exhaust can usually be connected to the heater. When a condensing plant is installed the steam from the air and feed pumps or other auxiliaries may be diverted to the feed-water heater. With an open heater, about one-sixth of the exhaust steam from the main engine will heat all the water from about 50 deg. to a temperature near the boiling point.

Where condensers are used it is often advisable to place a closed heater in the exhaust line between the engine and the condenser, discharging the feed water through this into an open heater into which the auxiliaries exhaust. The writer has seen closed heaters so clogged in the water space that nothing but a thin stream could trickle through. When such heaters are installed in connection with a condensing system they should be arranged with a bypass.

SUPERHEATED STEAM

It is surprising that more advantage is not taken of the use of superheated steam in pumping plants where the long stroke and slow speed of the engines make it especially suited to increased economy. Ordinarily, the efficiency of pumping engines can be increased from 5 to 25 per cent. by the use of superheated steam, and even with large high-duty triple-expansion engines a saving of 12 per cent. in steam has been recorded. For purposes of comparison it may be stated that the saving by using superheated over saturated steam will be approximately as follows for 100 deg. superheat: For a simple engine, about 15 per cent.; compound engine, about 14; triple-expansion engine, 12; steam turbine, about 10 per cent.

PUMPING PLANTS

It would be interesting to know how many pumping plants record each day the amount of water pumped, the pounds of coal consumed, the cost to evaporate 1000 gal. of water in the boiler plant, and whether the coal is doing the same or only one-half the work it did last month. Contracts are entered into for thousands of dollars' worth of coal per year and no means are taken to determine if 25 per cent. of the material is

worthless as fuel as compared to the sample car received. Again, the coal may be all right, but the plant may be in such a condition that 25 per cent. more fuel is required to do the same work. Such losses can usually be avoided either by a close inspection, by making the necessary tests at suitable periods and by a system of daily records, and the proper interpretations being made of such records; in regard to the latter, the personal factor is important. Constant and intelligent attention to the innumerable details of the plant cannot be slighted and have the plant operate satisfactorily. The superintendent cannot do all this, but the operating engineer directly in charge should be held responsible for his part.

Smoke

Legislation may minimize the smoke, but the ultimate desired results can never be accomplished without looking at the question as one of dollars and cents. In the first place the writer believes there is no such thing as a commercial smoke consumer, despite the fact of inventions and statements to that effect. Smoke cannot be commercially consumed, although it may be disguised or treated in such a manner that it has a less formidable appearance to the esthetic eye.

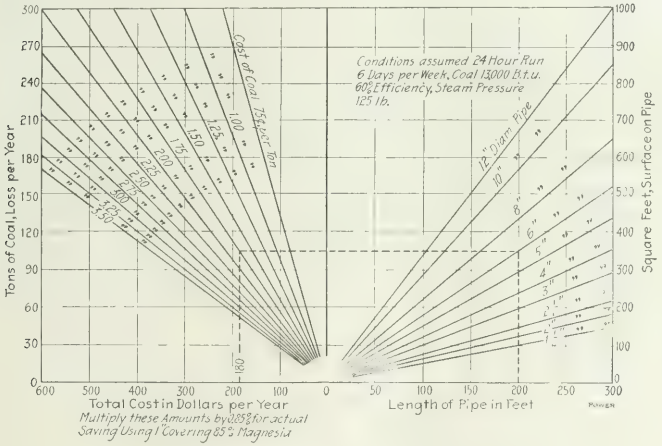


Fig. 2. Loss Due to Uncovered Piping

The only way to consume smoke commercially is not to make it, and engineers who have studied the problem recognize this as the first commandment in the smoke question. Smokeless combustion will not be general until the plant owner recognizes that he is wasting money.

Overloading boilers will not cause smoke; it is the lack of sufficient furnace space, coupled with the lack of appliances or improper methods of firing, which is directly responsible for the smoke. The common method of purchasing a boiler and building a brick wall around it and placing above a low stack—building the entire unit without regard to the ordinary principles of combustion—is the cause of great loss annually and probably does more to keep up the smoke-nuisance agitation than any other thing. The principles of combustion and the prevention of smoke are not mysterious.

To accomplish this it is necessary that all the products of combustion be consumed before touching the cold surfaces of the boiler. To do this requires good draft which means a high stack if natural draft is used. It means a properly designed furnace that should not be so cramped that gases cannot be properly burned before reaching the comparatively cold boiler and it means proper handling of the fuel whether by mechanical devices or by hand. Furthermore, the boiler should be properly set up so that in a year's time the settings are not full of cracks or crevices which admit air and contribute to the inefficiency of the furnace both as regards smoke prevention and economy of combustion.

Packing in Steam Plants

With the innovation of the steam engine came many accessories, most of which were crude in design, principle and material. None was more indispensable than packing for cylinder heads, steam chests, pipe-flange joints, etc. Up to about 1850 the most commonly used material was a composition of red lead, hemp and oil made into putty by the engineer or his helper and plastered on the flange joints, which were then screwed up tightly and the putty or packing was allowed to dry or set before the pressure was applied, which at this period did not exceed 60 lb. per square inch.

The next development was approximately in the year 1860, when cloth insertion packing was introduced, this probably being the first rubber or gum-sheet packing manufactured. It was composed of rubber composition with insertions of duck or sheeting, and was used between 1860 and 1875, when steam pressure did not exceed 80 lb. per square inch.

After this period came the plumbago and rubber compositions, called self-vulcanizing packings; this form had to be vulcanized or baked into the joint, a process requiring considerable labor, time and expense. They were more durable and satisfactory, however, under conditions then existing than preceding packings.

The next important advance made in the development of rubber-sheet packing was in 1886, when several semi-vulcanized rubber-composition packings appeared. These packings did not require as much baking in the joint and soon became popular.

A packing composed of rubber and asphaltum, which was suitable for water and other liquid conditions next claimed the engineers' attention.

During the period from 1900 to 1910, steam pressures have increased from 80 to 200 lb. and over in stationary plants. This increase has brought a corresponding rise in temperature which has been still further increased by the practice of superheating the steam. The wider use of the air compressor, ice machine, gas engine, superheater, etc., has also created extreme temperatures which demand a packing that can meet exacting conditions.

Composition packings have been perfected having great resistance to extreme heat as generated under high pressure. The basis of this material is pure asbestos fiber, the fibers being treated with a waterproof compound to prevent them from absorbing moisture. The composition is compressed under pressure into a compact homogeneous texture sheet packing in various thicknesses and of high tensile strength. Such a packing is unaffected by condensation from steam; and if properly made retains its pliable resilient qualities and does not become hard or brittle. It will, of course, conform to uneven surfaces and is suitable for gaskets on air compressors, and as packing so constructed is suitable for high-pressure and superheated steam, it is, of course, also suitable for use with low-pressure and saturated steam.

What demands will be made upon packing in the future remains to be seen.

Although in recent years the price of electric energy has been reduced under the stress of competition from the small isolated plant, the price of central-station service is still so high that only in exceptional cases can one afford to forego the cheaper and independent production by the private plant.—Prof. Josse, in *Neure Kraftanlagen.*

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

A German Rural Power Plant

By Dr. Alfred Gradenwitz

In view of the more and more difficult conditions applying to German agriculture, there is an increasing necessity for using machinery in connection with most agricultural operations. This tendency has led to the installation of a number of rural power-transmission plants, with electric motors for driving the agricultural machines. A new development in this connection has been recently made by the installation of rural power-transmission plants in connection with embankments in the hilly country of East Germany, where no considerable heads are available.

The Radaune Valley embankment plant, between the sluices of Boelkau and Prangschin, near Danzig, is the first of these installations, and presents a number of interesting features. As there was no rocky soil to serve as foundation for a masonry dam, it was necessary to resort to an embankment containing a core of boulder marl, the slopes of which on the water side are protected by rubble in the lower third and by granite slabs in the two upper thirds against the impact of waves, whirls and floating objects. The opposite slope was fixed with turf on a layer of vegetable soil.

This embankment (see Fig. 1), the crest of which is 144 ft. above the average water-level of the Baltic and 57 ft. above the lowest level of the Radaune, allows the river to be dammed up to a height of 47½ ft., thus producing a basin of a normal capacity of about 120,000,000 cu.ft. and covering an area of about 173 acres. In order to enable the water-level to be increased or lowered, as the case may be, even emptying the basin, partly or entirely, a bottom discharge has been installed, traversing the embankment, which mainly consists of a big wrought-iron conduit 59 in. in diameter and a control gate. In order to prevent flooding in the case of high water, an automatic overflow or spillway was provided, consisting of an open canal which descends in cascades toward the river.

Fig. 1. Embankment and Power House; Discharge Gate is in Concrete Pit in Foreground

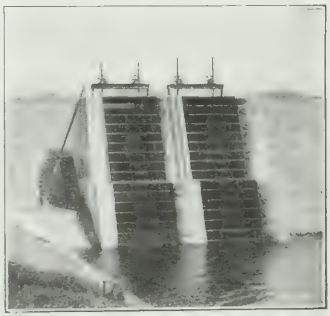


Fig. 2. The Head Gates

The power-house equipment comprises two self-contained generating sets, each of which has its own penstock, entrance gate and rake. Each penstock is controlled normally by means of a quick-acting gate fitted at the end immediately ahead of the turbine and operated from the generator room; this is used for starting, stopping and draining the turbine, the main head gate being used only for shutting off the entire penstock. Two iron-concrete conduits, 6 ft. in clear diameter and 131 ft. long, lead through the embankment to the main head gates. The water flows through these conduits at a maximum speed of about 6½ ft. per second. In front of the power house these iron-concrete con-

duits terminate in wrought-iron pipes of the same diameter.

The two turbines are Francis twin machines in steel housings with axial water admission and horizontal shafts. They are direct coupled to the electric generators. The rear bearing of each set is a thrust bearing and is accessible through the pit. The turbine shaft proper has only this one bearing, being rigidly coupled to the dynamo shaft by a forged-on flange; the complete turbine and dynamo set has only three bearings and is accordingly of relatively small length. The steel housings of the turbines are 98½ in. in clear diameter and are connected with the control valves by conical fittings. This arrangement greatly simplifies the water admission and reduces the loss of head between the rake and the turbine. In fact, the loss of head in the rakes, head gates, conduits and control gates is only about 12 in. under full load.

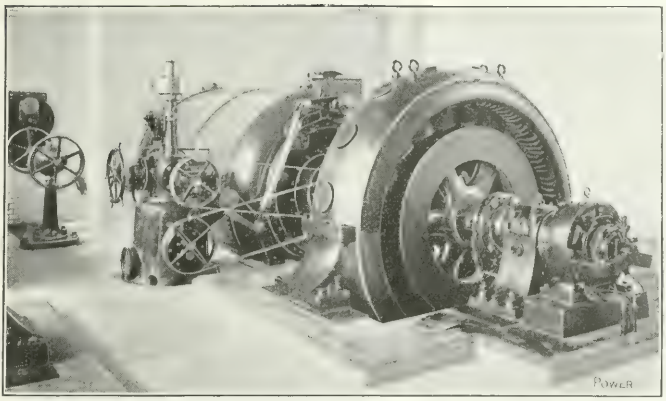


FIG. 3. A GENERATING UNIT IN EMBANKMENT POWER HOUSE

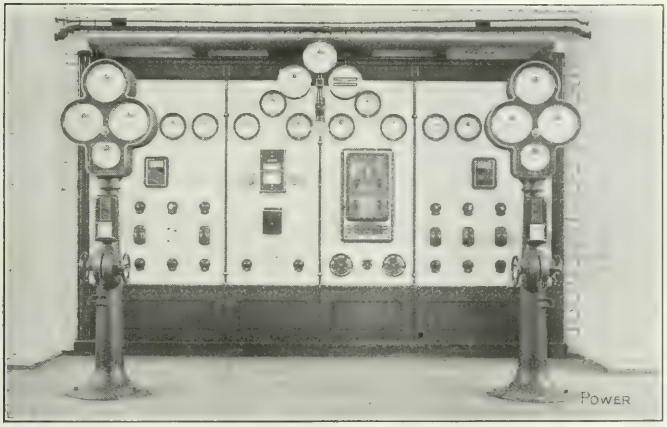


FIG. 4. SWITCHBOARD AND CONTROL COLUMNS IN POWER HOUSE

As the embankment is compelled to supply to the mills situated on the river the whole or a given portion of the water flowing into the basin, an electrical level-signaling device has been installed above the basin for indicating the water admission. This allows the amount of water flowing from the upper pond into the storage pond to be gaged at any moment. The water consumption of the turbines is recorded by Woltmann apparatus.

POWER HOUSE EQUIPMENT

The two three-phase alternating-current generators driven by the turbines are of the usual revolving field-magnet type with their exciters driven from the ends of the shafts, as shown in Fig. 3. The field magnets are excited at about 110 volts, and the machines deliver three-phase currents at 8000 volts and 50 cycles per second, running at 300 r.p.m. The output of each generator is 550 kw. with unity power factor. The exciters are 9-kw. dynamos. All of the electrical equipment is of Siemens-Schuckert manufacture.

The switch-gear is located in an annex, and all parts carrying high-tension current are placed in closed compartments, the plant being controlled in the low-tension circuits. The instruments and switch handles for starting and controlling the two generators are installed on two control columns located on a platform in front of the switchboard, as shown in Fig. 4. The synchronism indicators are located on a bracket in the middle of the service switchboard, so as to be easily observed from either control column. The service switchboard comprises four marble panels and is built into the middle of the wall facing the machinery. Immediately behind the switchboard are arranged the field rheostats of the exciters. The high-tension

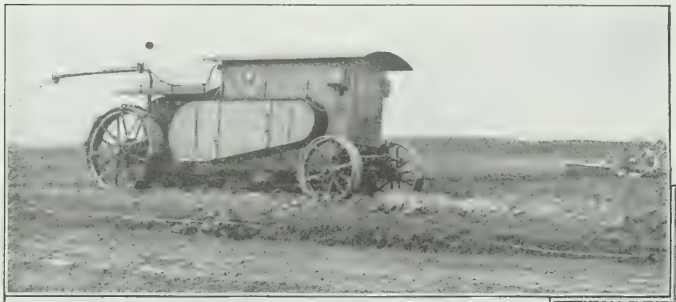
FIG. 5. HIGH-TENSION LINE CROSSING ROAD NEAR PRAUST

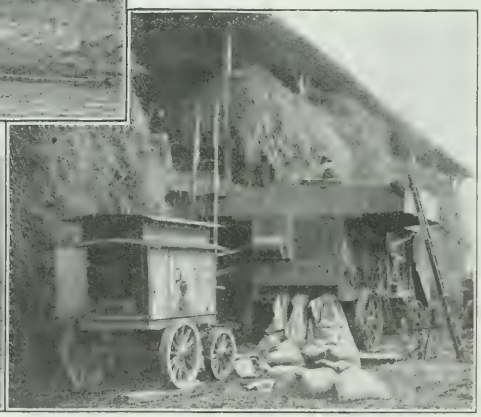
apparatus is also located behind the switchboard, in iron frames between massive partition walls and closed in by wire-gauze screens. The iron frames also support three-phase transformers through which current is supplied for lighting the power house and the attendants' houses.

DISTRIBUTION AND UTLIZATION

The electrical energy generated at the power house is mainly distributed by six transmission lines at the generator potential of 8000 volts. Another 8000-volt transmission line will possibly be added later. Two of the 8000-volt transmission lines run in a southward direction and are connected to form a loop. A third line, which runs eastward for a distance and then northward, is to be "tied in" with one of the two northward lines feeding the Muggau transformer station, whence two branch lines extend northward and westward respectively. In the western branch line, which supplies a considerable amount of energy for operating brick mills, the potential is raised to 15,000 volts in a 150-kv.-a. oil-cooled transformer. Excepting a section nearly 2 miles long, all the transmission lines are overhead. The main line is of hard-drawn copper wires about equal to No. 5 B. & S. gage in cross-section and the branch line wires are about equal to No. 7. The transmission lines are located about 23 ft. above the ground and are subdivided by a number of section switches. Fig. 5 shows a short stretch of one of the lines.

The high-tension current is reduced at the points of consumption to a working tension of 220 volts. As the electrical energy is supplied mainly to a number of isolated farms, the number of transformer stations is relatively large. Portable transformers with disk windings and dry insulation, which are rented out by the district management, allow those farmers possessing extensive tracts to do all their harvesting and other operations in the fields with the aid of motor-driven machinery. Some of these equipments are illustrated in the accompanying pictures, Figs. 6, 7 and 8.





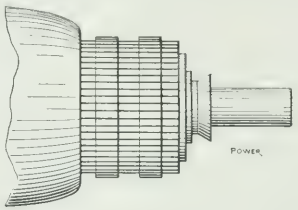
FIGS. 6, 7 AND 8. TRANSFORMER WAGONS SUPPLYING A MOTOR-DRIVEN PLOUGH AND TWO THRESHING MACHINES

LETTERS

A Kink in Undercutting

It had been the regular practice here to turn down the commutators of the exciter dynamos at least once a month, and shortly after taking charge, I had a small-sized imitation of a fourth of July celebration, when a commutator of one of the exciters burst, it having been turned down until the bars were too thin to resist centrifugal force. (I had previously notified the manager that it did not appear safe to run very long.) I tried soft and hard brushes with no better results from one than another on the commutators.

After finishing the first commutator I had to turn down, I made a small narrow tool with a nose as wide as the thickness of the mica between the bars, put it sidewise in the tool-post of the lathe, and cut the mica down about $\frac{1}{32}$ in. below the level of the bars by moving the tool carriage along; after cutting a strip I turned the armature, which was between the centers of the lathe, by hand from one space to the next, cut that down and turned the armature to the next strip, and so on until all were cut down alike. Then I turned the commutator bars down about $\frac{1}{16}$ in. in the narrow spaces between the parts of the tread that the brushes rode on, also at the ends, as shown in the sketch. Then I soaked the brushes in a mixture one-half kerosene and one-half engine oil for several hours.



MR. FRIES' FINISHED COMMUTATOR

One commutator has been running nearly a year and the other about three months. I put one hard brush opposite a soft one after soaking them, and from present indications commutator trouble is a thing of the past here.

Middleboro, Mass. J. W. FRIES.

Mr. Bates' Thawing Current

Referring to J. E. Bates' letter in the Jan. 30 issue of POWER, I think there must have been some other source of heat than the little half-ampere of current flowing through his supply pipe to the house. If he had stopped to figure a moment, he would have noticed that it took 400 times the amount of current in the first instance to thaw just three times the amount of ice. The warmth must have come through the ground—a thaw from below.

Roundup, Mont. L. EARLE BROWNE.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Oil Engines in a Hungarian Municipal Power Plant

The following abstract* describes the salient features of two 300-hp. oil engines in the municipal power plant of Torda (Hungary) and presents some operating results obtained from them.

Torda is a city of about 15,000 inhabitants, situated in the State of Transylvania. For a long time the authorities had contemplated adding to the 100-hp. Diesel equipment, which at one time sufficed to supply the electric street-lighting system as well as a limited number of private consumers, and recently the load increased so far beyond the capacity of the already overloaded plant that it was decided to enlarge it at once. A new power house was accordingly built and equipped with two 300-hp. Nicholson-Litzenmayer crude-oil engines, each direct-connected to a 260-kv.-a. Siemens-Schuckert alternator designed to deliver three-phase currents at 3100 volts and 50 cycles. The old 100-hp. Diesel engine and generator were retained and modernized.

The distribution of the three-phase currents is effected by means of the usual three-wire system and step-down transformers, ranging in size from 7.5 to 30 kw., which deliver to Y-connected four-wire secondary lines; from the secondary mains current is delivered either at 210 volts between main wires for power, or at 121 volts between the neutral and one main wire for lamps. The street-lighting equipment consists of 40-cp. metallic-filament incandescent lamps, and a few arc lamps.

The power house is a one-story brick structure with a basement of 8 ft. 4 in. pitch. In the basement are four electrically driven cooling-water pumps, two of the centrifugal and two of the piston type. The pumps take the hot jacket water from the engines and deliver it to a cooling tower about 20 ft. above the engine-room floor; from here it flows by gravity to the engine-cylinder jackets and the compressed-air tank cooling coils in the basement.

The engines of the new units are twin two-cylinder, horizontal machines, with the generator mounted between the two members of the twin unit as shown in Fig. 1. Each member of the unit is complete with its own valve-gear and air compressor. The revolving field-magnet of the generator serves as a flywheel, giving a 1:180 variation. The diameter of each cylinder is 5¾ in., the stroke 22⅛ in. and the speed 187.5 r.p.m.

Adjacent cranks are set in the same position on the crankshaft and the two cranks of one member of the pair are set at 180 deg. from those of the other. There are two explosions per revolution of the crankshaft, the engine working on the four-stroke cycle. Although each cylinder has a separate valve motion, the crude-oil supply pumps of all four cylinders are arranged around the valve-motion shaft of cylinder No. 1 (the right-hand cylinder in Fig. 1) and connected to a centrifugal governor which regulates the oil supply for varying load conditions.

One-half of the engine bed and the outside cylinder barrels of one pair are cast in one piece. The cylinder liner fits closely into a ring at both ends of the outer barrel. A brass ring between the two barrels at the crank end makes the joints water-tight. The head-end flanges of both barrels are slightly tapered and rubber gaskets between the two tapered

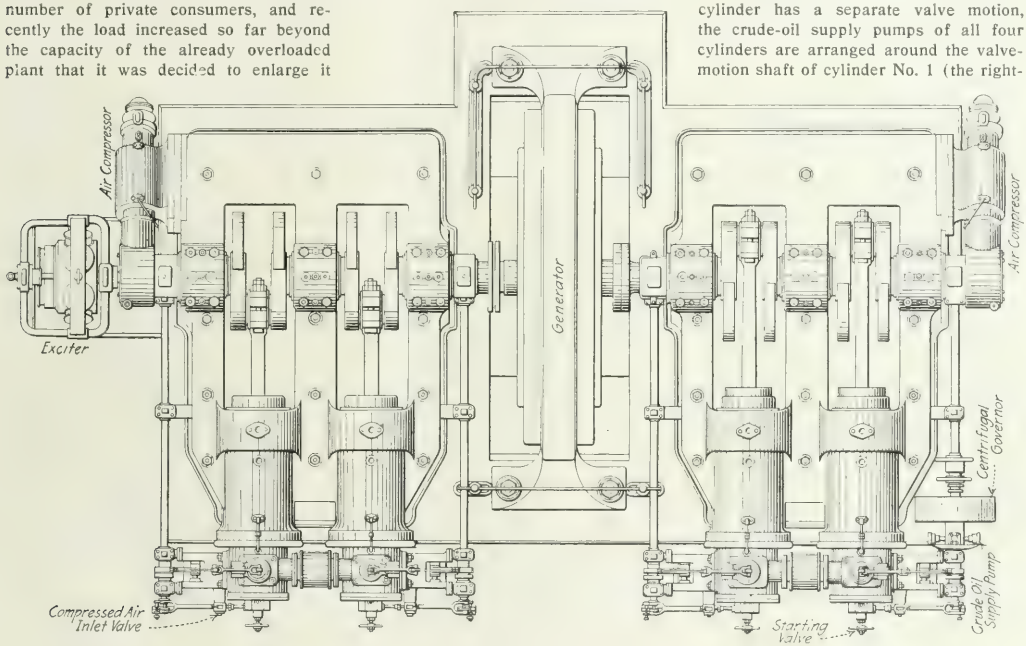


FIG. 1. PLAN VIEW OF A GENERATING UNIT IN THE TORDA PLANT

*Of a paper by Laszlo Bano, presented before the Hungarian Society of Engineers and Architects of Budapest. Translated by L. I. Oesterreicher for the Journal of the Society of Hungarian Engineers of America.

metallic surfaces serve to keep the joints tight and also allow the necessary play for the expansion or contraction differences of the liner and the outer barrel. The crankshaft is made of Martin steel in two pieces, a counterbored flange coupling fastening the two halves together.

A centrifugal oiling device lubricates the crankpins and all other shaft bearings have oil-ring lubrication; the pistons are fed by automatic oil presses.

The pistons are of the long trunk type, packed by eight rings each. The cross-head pin is made of Mannesman compound cast steel with glass-hard outer working surfaces and soft cores.

The cylinder breech is a separate piece, made of cast iron, with a jacket for water cooling. On one side the breech fastens to the end of the cylinder barrel; the other side is closed by a removable cast-iron head, allowing easy and quick access to the interior.

The most important part of the engine, the air-nozzle head, is a combination of starting device, oil warmer and carbureter, and assists in igniting the charge. It projects through the center of the cylinder head. Figs. 3 and 4 show two cross-sections at 90 deg. to each other. Each cylinder is equipped with this attachment, so that the engine may be started with whichever piston is in good starting position. By turning the handwheel *C* the valve stem *D* opens the ball valve *E*, through which compressed air at 950 lb. pressure per square inch flows through passages *H* and *F* into the cylinder and starts the engine, after which the ball valve *E* is closed. During the suction stroke, one of the crude-oil pumps *M* around the lay shaft (Fig. 5) forces the necessary fuel oil through the check valve *O* into the oil-warming chamber *B*, which is in constant communication with the explosion chamber. Immediately before the dead center is reached, the valve mechanism opens the compressed-air inlet valve *G* and compressed air rushes into the chamber *B*, when the previously deposited and warmed oil becomes mixed with the inrushing air and is carried into the explosion chamber. At the end of the compression stroke, the temperature in the cylinder attains or exceeds the ignition temperature of the oil, igniting the mixture of air and oil.

The valve-motion shaft carries three cams which operate the air inlet and exhaust valve rods through rollers. Beside the cam for the compressed-air inlet valve, a higher cam controls the air supply at the start. By means of a spring pawl the air-inlet valve-rod may be shifted to either the starting or the running cam; this arrangement makes it unnecessary to provide a separate starting valve; moreover, the engine is self-starting when it stops in a favorable position with respect to the starting cam of the compressed-air inlet valve.

Another important feature of the engine is the crude-oil supply pump and its connection to the centrifugal governor. Fig. 5 shows the four pumps arranged equidistantly around the lay-shaft, which is also the governor shaft. The eccentric *J* forces the plunger pistons inward and they are returned by springs.

Within the eccentric *J* another eccentric *I* will be noticed; this second eccentric is pinned to a disk which is rotated by the centrifugal governor. Turning one eccentric within the other will change the eccentricity and correspondingly change the stroke length of the oil-pump pistons, thereby regulating the crude-oil supply to the cylinders. The governor is of the ordinary weight and spring type, and is provided with a handwheel and a small electric motor by means of which the governor spring tension can be adjusted to get the proper speed. The motor is wired for remote control from the main switchboard, giving complete speed control to the operator for synchronizing and operating the generating sets in parallel.

The necessary compressed-air supply on account of its high pressure (850 to 1050 lb. per square inch) is compressed in two stages: the first attains a pressure of 104 lb., and the air then passes through a cooler to the high-pressure cylinder, and after being compressed to the required pressure, to a second cooler whence it passes into the air tanks.

The low-pressure pistons are of cast iron and have ordinary ring packings; the high-pressure pistons, in addition to rings, have labyrinth packings. The air compressor suction valves take air from the basement, thus eliminating the rattling noise from the engine room.

The daily fuel-oil supply is stored in a small tank mounted on the outside of the building wall near the engines, and the oil flows by gravity to the four supply pumps of each unit. The bulk of the oil is stored in two large reservoirs built in the ground in the power-house yard and the supply for one day's run is pumped into the smaller feed tank each day.

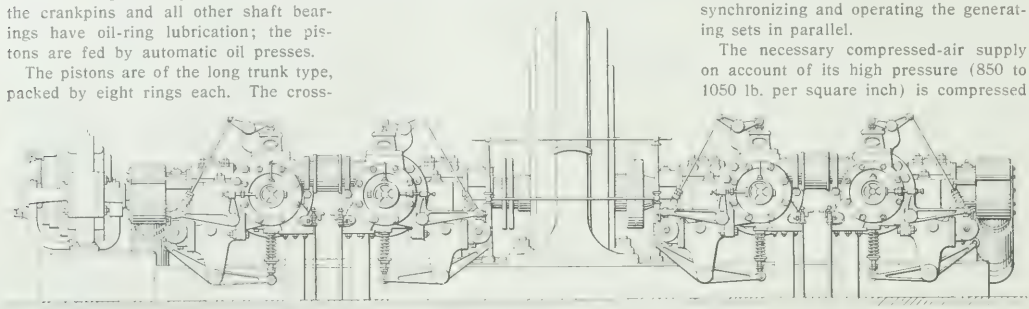


FIG. 2. BREECH-END VIEW OF A TORDA GENERATING UNIT

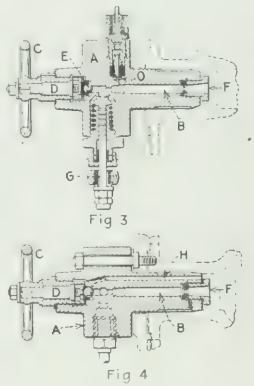


Fig 3

Fig 4

INLET VALVES

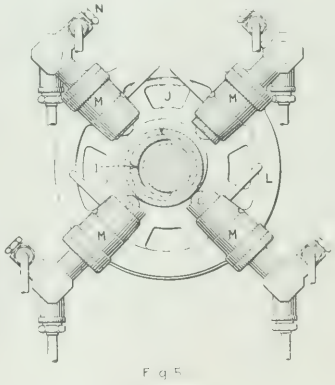


Fig 5

OIL PUMPS

Engine Performance

The fuel consumption per kilowatt-hour, measured at the switchboard, was guaranteed not to exceed the following rates:

At full load, 0.628 lb.; with 10% mixture, 0.690 lb.
At ¾ load, 0.716 lb.; with 10% mixture, 0.767 lb.
At ½ load, 0.870 lb.; with 10% mixture, 0.957 lb.
At ¼ load, 1.135 lb.; with 10% mixture, 1.248 lb.

per kilowatt-hour, with reductions to large consumers. A renting fee is charged for the wattmeters, ranging from 10c. per month for the small meters up to 60c. for the larger ones.

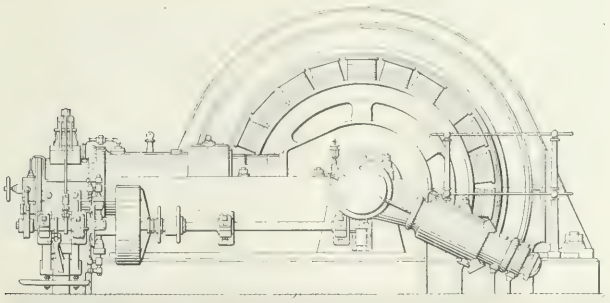


Fig. 6. View of Torda Engine on Governor Side

An official test was carried out under the supervision of a number of disinterested engineers; the results are given in the accompanying table. The price of 100 kg. of crude oil delivered to the power plant is 7 crowns, and assuming that the specific gravity of the oil is 0.88, the cost per U. S. gallon would be 2.4c.

According to the test results the cost of fuel per kilowatt-hour at full load delivered at the switchboard would be 0.4c. and at one-half load, 0.5c. The price per brake horsepower-hour at full load would be 0.268c., and at one-half load, 0.3c. After an eight hours' continuous run, during seven of which the engines were under full load, the temperature was taken at different points on the engines and generators, and it was found that the temperature of the seemingly hottest crankpin was 89.6 deg. F., or 19.6 deg. above the engine-room temperature. The maximum generator temperature was 113 deg., or 43 deg. above the room temperature.

The cost of the power plant and equipment was as follows:

Oil engines, generator and entire engine-room equipment	$106,644 00
Power-house building	22,347 50
Alterations to Diesel engine	2,600 00
Total	$131,591.50

Although owned by the city, the plant is entirely free from the cumbersome, old-fashioned city administration. There are three directors, presided over by the mayor, and a general manager, who is a professional engineer, has full charge of the plant and is responsible to the directors for its proper operation.

Electric energy is sold to small lighting consumers at 14c. per kilowatt-hour with a sliding-scale reduction according to the monthly energy consumption. For power purposes, energy is sold at 0.6c.

TEST RESULTS

Oil engine	131–134	127–130
Generator	7,451	7,452
Duration of test	4 hours	6 hours
Net output: average kilowatts by hourly wattmeter readings	198.7	189.1
Kilowatts absorbed by exciter	3.85	4.7
Total average output, including exciter	202.55	193.8
Voltage, mean hourly	2,875	2,881
Current, mean hourly	41	38.25
Revolutions per minute, mean	186.8	187
Average engine horsepower, indicated	441.63	418.85
No-load engine, horsepower indicated	120.08	120.08
Average engine, brake horsepower	321.55	298.77
Average electrical horsepower	266.50	253.60
Heat value of crude oil, approx	18,037 B.t.u.	18,037 B.t.u.
Total oil consumption per hour	131.285 lb.	127.534 lb.
Oil consumption per kilowatt-hour	0.66	0.675
Oil consumption per brake horsepower-hour	0.408	0.427
Oil consumption, indicated horsepower-hour	0.297	0.304
Mechanical efficiency of engine	72.8%	71.3%
Mech. and elec. eff. of engine-generator unit	60.3%	60.5%
Thermal efficiency with respect to indicated horsepower	47.5%	46.3%
Thermal efficiency in regard of brake horsepower output	34.5%	33.0%
Temperature of jacket cooling water (inlet)	59° F.	59° F.
Temperature of jacket cooling water (discharge)	98.6 to 107 deg. F.	104 to 120 deg. F.
Temperature of exhaust gases	509 to 644 deg. F.	554 to 688 deg. F.

CORRESPONDENCE

Care of Exhaust Valve Stems

J. W. Fries' article in the Mar. 12 issue of Power is of a great deal of practical value; he describes an easy means of meeting a condition that nearly every operator of internal-combustion engines will be confronted with sooner or later.

As soon as there is sufficient wear of either the valve stem or the guide for even a slight leakage of exhaust gas, it becomes nearly impossible to lubricate the stem because the extreme heat of the exhaust gas burns the oil, especially if the stem is not water-cooled.

My experience has been similar to that of Mr. Fries excepting that the valves and stems were not water-cooled, and that I bushed the guides instead of "sleeving" the stems.

The old stems were an inch in diameter, so I had new stems turned up from 1⅛-in. mild steel. These were driven into the valve heads and headed over on the opposite side.

Then I had the guides bored out to 1½ in. diameter, and put in brass bushings bored out to fit the stems except for a distance of about 1 in. near the center of the bushing, where the bore is made about ¼ in. oversize, leaving an annular pocket all the way around the stem, for holding a lubricant. A hole through the side leads to this pocket and I fill it with grease under pressure.

I keep extra bushings on hand and it is only a short job to drive out a worn one and replace it with a new one.

Earl Pagett.

Coffeyville, Kan.

Testing a Small Gas Engine with a Prony Brake

A simple prony-brake test of a 3-hp. gas engine brought out a feature of brake testing that might be helpful to some of the readers of Power.

The test was run on a single-cylinder engine having a flywheel 14 in. in diameter and designed to deliver 3 hp. at 650 r.p.m., working on the two-stroke cycle. The prony brake was a heavy home-made wooden affair having a lever arm 2 ft. long and a bearing surface of about 20 sq.in. Water was used for cooling. When the engine was running free it turned up about 830 r.p.m.

The brake was screwed up until a torque of 20 foot-pounds was registered and the speed was 700 r.p.m. So far so good; but when an additional twist, however small, was given to the thumb-nut the brake seized tight, stopping the engine short. This happened several times, and then it was suggested that oil should be used in place of water. This was done, with the result that the brake could be tightened down to obtain almost any speed within the limits of 400 and 830 r.p.m. The maximum horsepower, 3.2, was developed at about 670 r.p.m.

It seemed that the brake was so heavy and powerful that its efficiency as a brake had to be reduced by using oil before it could be practical for measuring such small power. In general, a brake should be as light as possible to stand the torque, and a fine-pitch tightening screw should be used to put the load on gradually.

Alan A. Slade.

Providence, R. I.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Piping a Dry Kiln

By W. H. Wakeman

Inasmuch as some of the dry kilns found in service are not piped according to approved designs, Fig. 1 is presented to illustrate several valuable points in this connection. It is proposed to take steam at 15 lb. pressure from a 40-hp. tubular boiler and heat a kiln about 200 ft. distant. This kiln contains about 5000 ft. of 1¼-in. pipe, laid in sections below the floor line, and the heating pipes pitch toward the boiler.

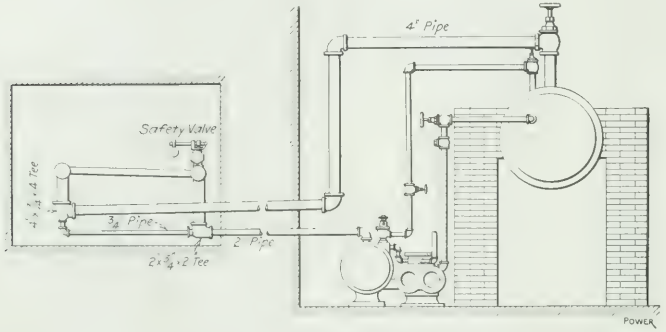


Fig. 1. Original Layout of Piping

As the pressure is light, the supply pipe must be large accordingly; hence 4-in. pipe should be used. Steam will be turned on and shut off by an angle valve, with the stem set vertically as shown. Sometimes a safety valve is located here, with a globe valve beyond it, but it is much better to have a separate outlet for surplus steam. While the kiln is in service two outlets are then available to prevent overpressure, but the safety valve ought to be large enough to constitute what its name implies. A 3-in. pop or a 4-in. lever valve will be sufficient.

The main steam pipe should pitch from the boiler throughout its entire length (except a short vertical piece) and the nearly horizontal part terminates in a 4x¾x4-in. tee. The ¾-in. outlet is necessary to drain the main pipe, as otherwise water will collect at this point and prevent a free flow of steam. As this pipe is connected directly into the main return pipe, it appears as if steam might flow directly back without going through the heating pipes, but it is too small to do more than provide a hot drip pipe, which is necessary to prevent water-hammer.

Water of condensation flows through the heating pipes into the return header, which is relieved of surplus pressure by a 2-in. pop, or a 2½-in. lever safety valve. This water falls into a 2x¾x2-in. tee and thence flows to a receiver, from which it is taken by a duplex pump and returned to the boiler.

As the available steam pressure is light, this service calls for a low-steam pump, with a steam piston about 6 in., a water piston about 2 in. in diameter, and a stroke of 6 in. or the equivalent of this design. The exhaust steam from this pump must be wasted, as it cannot be discharged into the heating system against full pressure.

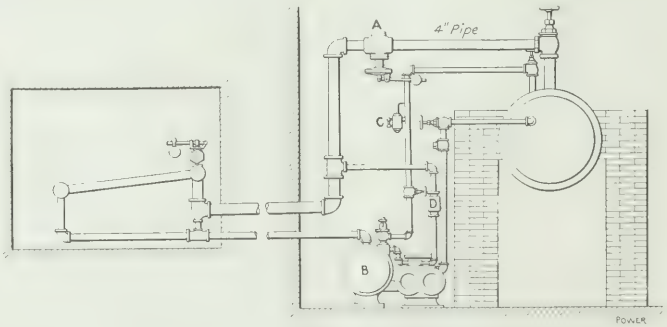


Fig. 2. New Arrangement Which Gave Better Satisfaction

Fig. 2 illustrates an improved piping system for the same plant, provided about 40 lb. pressure can be carried on the boiler. A reducing valve is shown at *A*, which lowers the pressure to 10 lb. The heating pipes pitch from the boiler; hence the nearly horizontal steam pipe terminates in a 4x¾x4-in. tee as before, but the ¾-in. drip pipe discharges directly into a 2x2x¾-in. tee. The entire return pipe is 2 in. in diameter and it discharges into a receiver *B*, from which it is taken by a duplex pump and returned to the boiler. As a higher pressure is available in this case, an ordinary pump can be used; size 5x3x5 in. will be sufficient. A sight-feed lubricator is shown at *C* and the separator *D* removes all oil from the exhaust steam. This can now be discharged into the heating system, thus preventing all loss of heat from this cause.

Steam Heating of Large Department Stores

By Henry D. Jackson

In the Feb. 27 issue, Davis S. Boyden gave some interesting figures on the cost of heating department stores. His figures, however, are entirely from the central-station standpoint; and while his article leads to the belief that it was far cheaper to heat the building as indicated and purchase the electrical power necessary, it is doubtful if such is the fact if we use Mr. Boyden's own figures for the coal required for furnishing this power.

The figures given in Table 4, on page 302, make it possible to figure the total cost for electric power, which amounts to $53,876.31, or approximately 1.94c. per kilowatt-hour. This, as may be noticed, is a low price for electric power generated in a central station.

In the article Mr. Boyden states that the coal which would be required in an isolated plant to generate the electric power for this building would be 6941

tons. A considerable portion of this would be available for heating, so that this total coal would not only represent that required for electric power, but, if the plant were properly operated, it would be available to some extent for heating purposes. With coal at $3 a ton, this would represent $20,823.

There is already in the plant 750 hp. in boiler capacity. The total boiler capacity required if 1500 kw. of generator capacity was installed, would not exceed 1250 hp., as boilers under the present rating can readily be crowded to give nearly double their rated capacity when occasion requires; therefore it would be easy to have one spare boiler with 1250 boiler horsepower installed in units of 250 hp. each. Then the total capacity of the plant would be 1500 kw., which would be ample for the purp

Mr. Boyden figures out the yearly load factor on this plant to be 9.3 per cent., and it is interesting to notice that the central station which furnishes power to this company has a ratio of the average consumption to the total connected load of but 9.9 per cent., which nearly approximates the same condition that he claims holds in the isolated plant. As the central station has absolutely no means of obtaining profit, or, what amounts to the same thing, of reducing the cost by the use of the exhaust steam, this ratio means far greater losses in the central station than it does in the isolated plant.

A plant of this type should not cost over $90,000; the building and the stack are already there and are required for other purposes than the generating plant. Taking the maintenance, depreciation, etc., at 12 per cent. would give a fixed charge of $10,800. Allowing a reasonable increase in the amount of labor would make the total cost for labor $6000; water, $1300; supplies, etc., $1500, making a total cost for heating and electric power of $40,423, or a saving of approximately $15,453 over the purchasing of power alone, in accordance with Mr. Boyden's figures, and it is to be noted that no fixed charges are made upon the heating plant, so that the actual saving would be considerably greater. In these figures it has been assumed that Mr. Boyden is correct when he says that it will take 5 lb. of coal per kilowatt-hour. I do not believe that a similar plant would need anything like 5 lb. per kilowatt-hour. While light is required practically day and night, the amount for the latter is comparatively small. This, however, would readily be taken care of without a material waste of coal if the generating units were properly proportioned, and under the conditions of a heating system properly arranged, the back pressure should be negligible; therefore, 4 lb. of coal per kilowatt-hour should be ample for all purposes, and would reduce the coal cost to $16,700, or the total cost to $36,323, including fixed charges.

As the plant now operates, the heating cost is $8582.29 and the electric power costs $53,876.31, making a total cost of $62,458.60. This makes a saving of $26,135.60, neglecting the interest, maintenance and depreciation charges on the heating plant which would materially increase the saving.

Fig. 3 of Mr. Boyden's article is decidedly interesting to the illuminating engineer. According to the curve of kilowatts of electrical energy supplied, it might be imagined that there were no windows at all in this building, as the load comes on shortly after 8, rises very rapidly until 9, gradually increases until 5, and then rapidly drops off; in other words, the effect of the increasing light due to the rising sun or to the increasing daylight has absolutely no effect in reducing the amount of power required. This condition of affairs is hardly consistent with that in most establishments, for as the day brightens, it would be natural for the electrical energy required for light to diminish.

As a matter of fact, these buildings get light from two sides, have very large window surfaces, and should be fairly well lighted during daylight hours. It might be thought that Mr. Boyden's curve is one taken from a dark, gloomy day rather than from a typical, clear winter day. If not, the building manager is decidedly remiss in that he apparently does not reduce the amount of light used artificially in accordance with the amount of light available from outside sources.

It is also interesting to notice that if the cost of heating as given in Mr. Boyden's paper is subtracted from the total cost of heating and electric power, as it would be in the case of an isolated plant, the cost of electric power per kilowatt-hour would be approximately 1c. as against 1.94c. as purchased.

In the *Isolated Plant* for April appears an article criticizing Mr. Boyden's paper. In the course of the article it is stated that if an isolated plant had been installed the fuel bill per year would amount to $25,000.

Mr. Boyden states that $5718 was spent for 1920 tons of fuel, almost exactly $3 per ton. The total kilowatt-hours are given as 2,776,370, and the evaporation from and at 212 deg. as 9.3 lb. of water per pound of coal. Dividing $25,000 by 3 would give 8333 tons of coal, and at 2000 lb. per ton this would mean:

$$\frac{8333 \times 2000}{2,776,370} = 6\ lb.$$

per kilowatt-hour in fuel, disregarding the heating for the time being. What kind of an engine as large as 500 kw. would show such a poor performance? Mr. Boyden himself only allows 5 lb. of coal per kilowatt-hour, and surely no one should accuse him of being mean from his standpoint and interest.

There would be only about 176 tons of coal required for live-steam heating under the worst conditions, and a large portion of the 200 tons allowed for kitchen and hot-water service would be heated by exhaust steam in the case of an isolated plant being installed.

If 93 lb. of steam are generated per pound of fuel from and at 212 deg. F., the steam consumption per kilowatt-hour at the switchboard would amount to nearly 56 lb. This would be equivalent to 42 lb. of steam per brake horsepower-hour which is well within the range of an old-fashioned slide-valve engine.

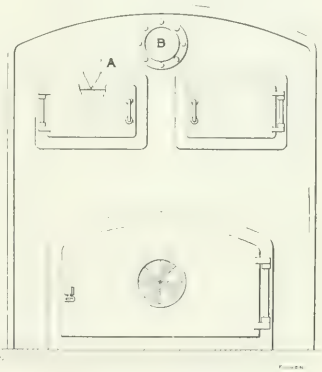
IRA N. EVANS.

New York City.

A Temporary Repair

A low-pressure steam-heater section became checked or cracked as shown in the drawing at *A*. It leaked so badly that it became necessary to provide some means of repair so that steam could be maintained. A new section was ordered from the factory, but a delay of two to three weeks was necessary. The heater was needed more or less until the new section came, so the following method was adopted:

The section was taken out from the setting, and the crack scraped with an



SHOWING CRACK IN SECTION

old file until a crevice $\frac{1}{16}$ in. deep was found. It was scraped on the inside as well as the outside as it could be got at through the steam hole *B*. The crevices were washed with acid, rinsed with water and filled with the following paste: Smooth-On, sal ammoniac and water. This paste was worked in well and left to stand for 24 hours. The section was put back in place and has been working under a pressure of 8 lb. for five or six weeks.

J. HUG.

Ames, Iowa.

Steam Power Plants

The January *Proceedings* of the Engineers' Society of Western Pennsylvania contains a very interesting paper on "Steam Power Plants," by O. S. Lyford* and R. W. Stovel,† which was read at the December meeting of that society.

Owing to the breadth of the subject the paper was confined to steam-turbine plants using bituminous coal for fuel. Ten plants of this character were selected ranging in capacity from 79,000 down to 1000 kw., and the considerations affecting their design together with cost data are taken up.

Referring to Table 1, which shows the probable limits of cost of stations belonging to the class referred to, some of the costs apparently do not have any specific relation to the capacity installed and the probable range in such costs is a matter of previous experience. This refers to such items as "preparing site," "yard work" (such as condensing water flumes, etc.) and "service equipment."

It was pointed out that the foundation costs would range from $1.25 to $4 per square foot of building-plan area, depending upon the character of the soil. The lower figure would cover simple concrete footings or good bearing soil while the necessity for piling, waterproofing, excessive rock excavation, etc., would bring the cost near the higher figure. The plan area will average from 0.8 to 1.5 sq.ft. for each kilowatt of capacity installed, depending upon the size and arrangement of the units.

The building costs will vary from 8 to 12c. per cubic foot of building volume, and there will be required from 50 to 100 cu.ft. of volume per kilowatt of capacity, making from $4 to $12 per kilowatt.

The boiler-room equipment costs are shown in Table 2. These represent labor and material only and do not include any general charges such as engineering or supervision. The unit costs in Table 2 relate to rated boiler horsepower, whereas those in Table 1 are based upon kilowatts capacity of the generators. These costs, however, generally vary directly with the rating of the boilers regardless of how much boiler capacity may be installed to serve a given generator capacity.

In regard to economizers, the authors state that: "With 50 per cent. annual load factor and coal costing $3 or more per ton, the saving with economizers is enough to more than cover their fixed charges and maintenance. These conditions may vary 20 per cent. and the economizers still show an annual saving. When the coal costs less than $3 per ton economizers are seldom justified by heat economy only, although they may be justified from the standpoint of heat storage. With a rapidly fluctuating load, they aid the boilers in meeting sudden demands."

As to the selection of condensers, it is the authors' opinion that since surface condensers will cost from $1 to $3 more per kilowatt than the mixing type, their use must be well justified. Since there is now little difference in the amount of vacuum which either type may be depended upon to produce, the selection is governed almost wholly by the condensing water supply. If this water is suitable for boiler feed there is usually no good reason for the surface type. In general, it is assumed that if the cost of feed water does not exceed 6c. per thousand gallons, and if the average load on the plant does not exceed one-half the maximum load, then surface condensers are not warranted.

Table 3 gives a summary of operating

TABLE 1. COST OF STEAM TURBO-ELECTRIC GENERATING STATIONS FROM 2000 TO 20,000-KW. CAPACITY, BASED ON MAXIMUM CONTINUOUS CAPACITY OF GENERATORS AT 50 DEG. RISE.

	Dollars per kilowatt High	Low
Preparing Site—Dismantling and removing structures from site, making construction roads, tracks, etc.	$0.25	....
Yard Work—Intake and discharge flumes for condensing water, railway siding, grading, fencing, sidewalks, etc.	2.50	$1.00
Foundations — Including foundations for buildings, stacks and machinery, together with excavation, piling, waterproofing, etc.	6.00	1.00
Building — Including frames, walls, floors, windows and doors, coal bunker, etc., but exclusive of foundations, heating, plumbing and lighting	12.00	4.00
Boiler-room Equipment—Including boilers, stokers, flues, stacks, feed pumps, feed-water heater, economizers, mechanical draft and all piping and pipe covering for entire station except condenser water piping	24.00	12.00
Turbine-room Equipment—Including steam turbines and generators, condensers with condenser auxiliaries and condensing-water piping, also oiling system, etc.	22.00	12.00
Electrical Switching Equipment — Including exciters of all kinds, masonry switch structure with all switchboards, switches, instruments, etc., and all wiring, except for building lighting	5.00	2.00
Service Equipment—Such as cranes, lighting, heating, plumbing, fire protection, compressed air, furniture, permanent tools, coal and ash-handling machinery, etc.	5.00	2.50
Starting Up—Labor, fuel and supplies for getting plant ready to carry useful load	1.00	0.50
General Charges—Such as engineering, purchasing, supervision, clerical work, supplies, watchmen, cleaning up, etc.	6.00	3.00
Total cost of plant to owner, except land and interest during construction	$83.75	$38.00

TABLE 2. BOILER-ROOM EQUIPMENT COSTS PER RATED BOILER HORSEPOWER

	Dollars per horsepower High	Low
Boilers, exclusive of masonry setting	$11.00	$8.00
Superheaters	3.00	....
Stokers	5.50	3.50
Masonry setting for boilers	3.50	2.00
Flues	1.50	0.75
Stacks	4.00	2.00
Economizers	4.00	....
Mechanical draft	3.00	....
Feed pumps	1.50	0.50
Feed heaters	1.00	0.40
All piping and pipe covering	10.00	6.00
Coal chutes and ash hoppers	1.25	....
Various items, such as indicating and recording meters, damper regulator, ladders and runways, painting, etc.	1.00	0.50
Totals	$50.25	$27.15

TABLE 3. SUMMARY OF OPERATING RESULTS

	Range of practice	
B.t.u. per pound of fuel	14,000	....
Average yearly overall boiler and furnace efficiency	50	70
Effective B.t.u. per pound of fuel	7,000	9,800
Boiler pressure, pounds per square inch, gage	125	190
Superheat, degrees Fahrenheit	....	125
Average feed-water temperature, degrees Fahrenheit	120	200
B.t.u. per pound of steam (approximate)	1,100	1,100
Pounds of water evaporated per pound of fuel (actual)	6.36	8.91
Pounds of fuel per standard boiler horsepower	4.76	3.40
Average overall station water rate per kilowatt-hour	30	20
Pounds of coal per kilowatt-hour generated	4.72	2.25
B.t.u. in coal per kilowatt-hour generated	66,000	21,500
Thermal efficiency of station, per cent.	5.2	10.8

results based on common practice where bituminous coal of about 14,000 B.t.u. per pound is used.

Long Distance Transmission Record

What appears to be the world's record in long-distance transmission was attained on Apr. 1, when the dynamos at the Great Falls (N. C.) plant of the Southern Power Co. sent high-tension current over a circuit of 330 miles. This was accomplished when the test of connecting the lines of the Southern Power Co. with the wires of the Yadkin River Power Co. on an interchange basis was made. From the Great Falls plant on the Catawba River the power was transmitted over the lines of the company to Durham and thence to Raleigh.

"I've been going a pretty swift pace for years," said the flywheel.

"Yes, and you'd have been broke long ago if it wasn't for me," replied the governor.

*Consulting engineer, with Westinghouse, Church, Kerr & Co.

†Mechanical engineer, with Westinghouse, Church, Kerr & Co.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. and Treas. ROBT. MCKEAN, Sec'y.
505 Pearl Street, New York.
122 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 74, Berlin, N. W. 7.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 28,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Steam in Gas Producers

Though it is true that the introduction of steam into a gas producer has been proved by actual experience to be necessary for practical operation, it is theoretically a doubtful practice. There are three reasons for adding steam to the blast of a gas producer: to lower the temperature of the fuel bed and thereby prevent the fusion of the ash, resulting in the formation of clinkers; to reduce the loss of heat in the gas leaving the producer, and to prevent destruction of the walls of the generator by fusion with the ash.

By reducing the temperature of the fuel bed the formation of CO from CO_2 and C is retarded and consequently the capacity of the producer is lowered. The introduction of a dry blast enhances the production of CO and lowers the amount of CO_2. Results of tests have further shown that the higher the temperature of the fuel bed, within practical limits, the better will be the quality of the gas. The reduction of the heat losses in the gases leaving the producer, due to the addition of steam to the blast, is brought about by certain reactions that absorb a part of the energy which would otherwise leave the producer in the form of sensible heat in the gases. These reactions make available this energy for use in the gas engine or for heating purposes and tend to increase the efficiency of the plant. The high percentage of CO_2, however, which results from the introduction of relatively large quantities of steam makes it debatable whether a real gain in efficiency is accomplished.

It is well known that the use of an excessive amount of steam impairs both the quality of the gas and the capacity of the producer. On the other hand, an insufficient amount is, perhaps, almost as bad and will result in added expense for the removal of clinkers, cleaning and frequent renewals of the brick lining.

The right proportion of steam to air must be determined for each individual installation and, although certain percentages have been established in a general way, local conditions such as the type of generator, the character of the coal, the relation between the generator capacity and the gas requirements, etc., enter into the problem to such an extent as to be determining factors. For example, a larger proportion of steam is required to gasify coal that has a high percentage of ash of a low fusing point, in order to keep the temperature of the fuel bed down and prevent clinkering. Again, if the capacity of the producer is ample for the gas requirements and it is not necessary to push it to its maximum capacity, then the supply of steam may be sufficiently large to insure a longer life for the brick lining. In all cases, the proportion should be regulated to suit the operation of the producer and the amount of blast used.

Explosions of Second Hand Boilers

Of the numerous recent boiler explosions, not one to our knowledge has occurred in a modern power plant. Boilers used at sawmills, small refrigerating plants and for farm work have led the list and when their age and the usage they have received are taken into consideration, the reason is evident. They are old and worn out.

Men well versed in boiler principles agree that these explosions are due to weak parts which cannot withstand the stress brought upon them and that faulty design or carelessness is the cause of this weakness. But notwithstanding this, well designed boilers, and boilers where careless operation has not been a factor, do explode.

There are boilers which in some localities are not considered well designed that have been in operation a quarter of a century or more, and they are still in use. Most of them are made with single-riveted lap joints and the majority of them have been more or less abused.

In many instances, such boilers are not discarded until the demand for

greater boiler capacity forces them out; then they find their way to some quarry, sawmill, or the like, where they usually end their career by exploding.

In most states there is no law prohibiting old, discarded boilers from being sold and again put into operation, nor is there a law that will hold the owner for manslaughter or any other kind of homicide when his old, second-hand boiler explodes and kills several ignorant, unsuspecting workmen.

Although the American Boiler Manufacturers' Association is making commendable efforts to reduce boiler explosions to a minimum by adopting uniform boiler specifications, these efforts cannot effect the safety of the boilers now in operation. In after years boilers which are built under uniform specifications will be safer for a longer period, but if they are allowed to be sold and set up for use after once being discarded, there will be as many boiler explosions at sawmills and other similar plants as at present.

When state laws are enacted prohibiting the use of old and unsafe boilers, the number of explosions will be reduced, but if men are allowed to jeopardize human lives by installing old boilers just because they can be bought cheap, the rate of boiler tragedies will continue undiminished.

Protection from such occurrences demands the enactment of a law prohibiting the practice indicated and prescribing an adequate punishment for the owner who violates it.

Power Plant Operating Costs

It seems to be the exception rather than the rule to give any credit to the steam or power plant for the product it supplies to the rest of the factory. It is lamentable that such a condition obtains because it not only militates against the most economical operation of the power plant itself but also has a tendency toward the extragavant use of its product.

This does not apply, of course, to the larger establishments, as street-railway or electric-light and power plants, but there are innumerable smaller concerns all over the country where very little, if anything, is known of the actual cost of producing power, to say nothing of its economical generation and distribution. No matter whether the power distributed be in the form of steam, electricity, compressed air, hydraulic pressure, heat or any other, it is essentially a product of the department whence it comes and should be so considered, thereby giving due credit to the department producing it. This procedure is followed in all of the other departments, and in manufacturing establishments having more than one department of a similar character a keen rivalry often springs up as to which can produce the greatest volume or tonnage at the lowest cost. Although in most plants there is usually but one power house, so that there will be no possibility of rivalry, nevertheless these facts show that the power house is to some extent discriminated against.

The power plant, and everything connected with it, is not only deprived of any credit for the successful operation of the entire works, but it is often placed in the category of so called necessary evils. When everything runs smoothly and an ample supply of steam or other form of power is available, it is given no thought whatever, but as soon as something happens to entirely cut off or diminish this supply a complaint is immediately made regardless of the primary cause of the trouble, which can very often be traced back to the manager or superintendent who, perhaps, has failed to order some spare part or has refused to accede to the request of his engineer for some improvement or needed repairs to his machinery. In this case, the engineer is in no way responsible and should not be blamed. The lesson taught by such an experience, however, should be well learned and of profit.

The engineer can do considerable toward eliminating troubles in his department by doing his best with the equipment at hand, and if he shows proper willingness and ability he can often prevail upon his superior to grant at least the more modest of his requests. For example, he should make some effort at determining as closely as possible the cost of the power developed even if he has no measuring devices, such as coal weighers, water meters, etc., at his command. He can usually make a fairly accurate estimate of the amount of coal burned through a certain period and he can roughly get at the amount of water evaporated by figuring his feed-pump displacement. While such methods are crude, nevertheless the results obtained will be better than none at all because, by following the same method from week to week, his results will answer at least for comparative purposes, and with such figures as a basis for his arguments he has a much better chance of convincing the manager wherein he can reduce costs provided he is given the equipment requested.

He should also endeavor to determine the amount of power distributed to the various departments and make a charge for it at a fixed rate per unit of power. If he is not permitted to make a charge, he should keep a monthly record of it for his own information and because it might possibly be of use at some future time. There are several ways of arriving at a basis for such charges, but, to a large extent, it will be determined by local conditions. For example, power may be charged for at the same rate as if bought from a central station or at that which could be obtained if it were sold outside of the plant, or it can be fixed arbitrarily; the difference between this rate and the actual cost of production will determine the profit or loss, as the case may be, for the power station. If these things can be put down on paper with some degree of accuracy, there can be very little doubt but that benefits will result in proportion to the comparative relation between the plant in question and the ideal one.

The Rhode Island coal mine has been shut down just at a time when, in view of the general coal strike, its output would have been most in demand. There is no doubt that there is a large carboniferous deposit at this point, and that some use will be found for it in the industrial world. It is to be hoped that the investment, which this latest attempt to make it available has involved, may not be entirely lost.

It is said that from eight to ten thousand young men are annually enlisting in the ranks of the electric-light and power industry. Good old Opportunity will soon be working overtime if he is expected to provide a rising chance for this multitude.

Butt Joint Boiler Explodes at Salisbury, Md.

By F. A. Grier, Jr.

Salisbury, Md., was the scene of a boiler explosion which occurred Friday, Apr. 5, at 7:15 a.m., when one of two return-tubular boilers located in the No. 1 plant of the Salisbury Ice Co. exploded. The boilers supplied steam for two ammonia compressors, hoisting engines, private electric plant, etc. The exploded boiler, which was built about eight years ago, was 60 in. in diameter by 16 ft. long, having fifty-eight 3½-in. tubes. The shell was made of ⅜-in. steel, the heads being ½ in. thick. The boiler was tested last summer, and upon examination after the explosion it was found to be badly pitted and about 6 in. below the water line the shell was not more than $\frac{1}{16}$ in. thick in several places. About 90 lb. steam pressure was carried.

From the illustrations it may be noticed that the boiler has a butt-strap longitudinal joint. It is very seldom that a boiler with this type of joint explodes, and particularly one only eight years old. The girth seam, which, as usual, was a lap joint single-riveted, was apparently the initial point of failure. The boiler pulled in two and as may be seen in the photographs, the rivets pulled through the metal, which was greatly weakened from the pitting and corrosion previously mentioned.

The tubes were beaded on either end, and only eight were left in the head, as shown in Fig. 3. The other tubes were scattered in all directions at a distance of more than 200 yd. One-half of the boiler was carried 100 yd. and crashed

Fig. 1. Ruins of Boiler Explosion in Ice Plant at Salisbury

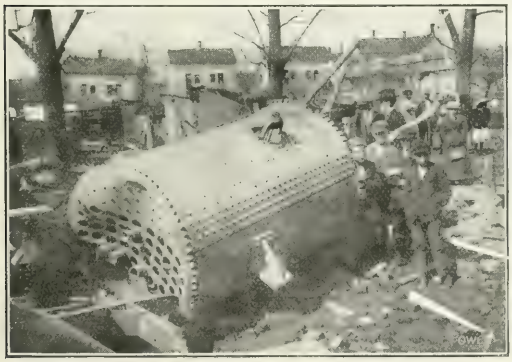


Fig. 2. Notice the Rivet Holes at the Girth Seam

Fig. 3. Eight Tubes Left in Rear Head

through the roof of and completely wrecked the stables of the Standard Oil Co., as shown in Fig. 4. The yoke to which the safety valves were attached was blown 75 yd. and was driven through the side of a grocery store, as can be seen in Fig. 5. One front furnace door weighing at least 300 lb. was blown directly across the street through a school-building window, tearing the stove in pieces and knocking down several desks.

The engineer and fireman, who had just gone to work at 7 a.m. were both killed instantly. A small boy was struck by a flying brick and had his leg broken; a minister who was attending the Methodist conference (which was in session, and being held in Salisbury) was struck by some part of the débris (perhaps a boiler tube as it landed less than 30 ft. from the church), and he was seriously injured.

The plant took fire immediately after the explosion and burned fiercely for about an hour, making the rescuing of the injured difficult. The loss is estimated at about $5000 as there was no insurance. This is the second boiler explosion in this county within 10 days, the other being a sawmill boiler, killing six and injuring three.

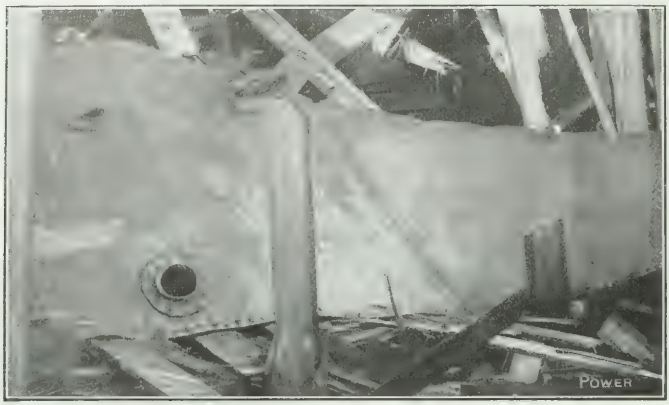


FIG. 4. HALF OF BOILER IN STANDARD OIL STABLES

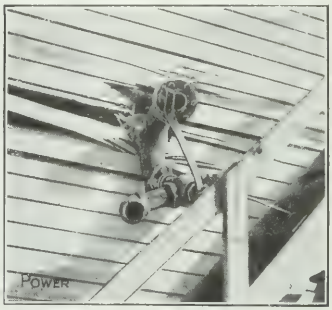


FIG. 5. SAFETY VALVE YOKE IN WALL OF GROCERY STORE

Calculation of Heat Value of Coal*

By O. L. Kowalke

Simple formula and chart for figuring the heat value from the proximate analysis.

Another chart which gives the heat value per pound of combustible when the percentage of fixed carbon is known and from this the heat value of the coal is calculated by a simple process in percentage.

*Abstract of article in "The Wisconsin Engineer."

The heat value of a coal may, in general, be ascertained by two methods: (1) By actual combustion in a calorimeter, (2) by calculation from its analysis.

There is little doubt that the calorimetric test of coal is the best, but as the cost of the necessary apparatus is somewhat high for those who have only occasional determinations to make, the analysis may be performed in two other ways: (1) An ultimate analysis of the coal may be made, which gives the proportions of carbon, hydrogen, oxygen, nitrogen, sulphur and ash. The heat value may then be computed from the known heats of combustion of carbon and hydrogen, according to various formulas. (2) An approximate analysis may be made which gives the moisture, volatile matter, fixed carbon and ash. By means of empirical formulas or curves the heat value can be deduced.

The ultimate analysis of a coal is a difficult and tedious process and requires long practice for its accurate execution. There have been various formulas proposed for ascertaining the heat value from this analysis, and there is considerable difference of opinion as to the correct method.

In view of the complexity of the ultimate analysis, several methods have been proposed for calculating the heat value from the proximate analysis which is not difficult to make. In 1902, E. Goutal published a formula (*Comptes Rendus*, September, 1902; *E. C. & M. I.*, April, 1907) for calculating the heat value from the proximate analysis, the formula being based on a large number of tests of French coals. The formula, in English units, is as follows:

$$B.t.u. = 14{,}760\ C + a\ V$$

where the B.t.u. refers to coal as received, C the percentage of fixed carbon expressed as a decimal, V the percentage of volatile matter expressed as a decimal, and a the constant. A table of values of a was constructed in terms of the volatile matter V' in the combustible. The heat value is computed by multiplying the weight of fixed carbon, in decimal form, by 14,760, and the volatile matter V actually found by constant a corresponding to the volatile matter V' in the combustible, and adding these two products.

Since the formula and values of a were determined on French coals, it seemed desirable to evolve a set of values for a from American coals. It also seemed desirable to retain the formula

$$B.t.u.\ per\ pound\ as\ received = 14{,}760\ C + a\ V$$

but to give a directly in terms of the percentage of volatile matter in the coal as received. Accordingly, about 200 analyses of American bituminous and semi-bituminous coals were used to compute a set of values for a, and these were plotted in the form of a curve, Fig. 1, with the values of a as abscissas and the values of V as ordinates. The heat value of the coal as received is then the sum of the products of: 14,760 times the fixed carbon (as a decimal), and a times the volatile matter V (as a decimal) in the coal as found. This method and the values of a will give a result approximating the calorimetric determination within 2 per cent.

The following is an example: A certain coal contains: Moisture, 11.58 per cent.; volatile matter, 34 per cent.; fixed carbon, 40.63 per cent.; ash, 13.79 per cent.

According to the curve in Fig. 1, the value for the constant, a, is 14,050 when

the volatile matter equals 34 per cent. Then, substituting in the formula,

Heat value = 14,760 × 0.4063 + 14,050 × 0.34 = 10,773 *B.t.u.*

per pound of coal as received.

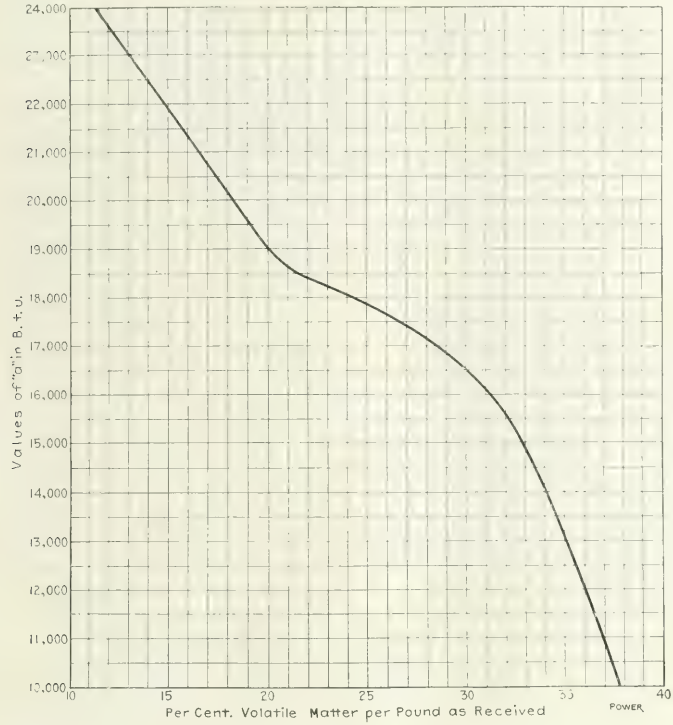


FIG. 1. CHART SHOWING HEAT-VALUE FACTOR FOR VOLATILE CONTENT OF COAL

The calorimeter test of this same coal indicated a heat value of 10,840 B.t.u. per pound. Thus the difference is only 67 B.t.u.

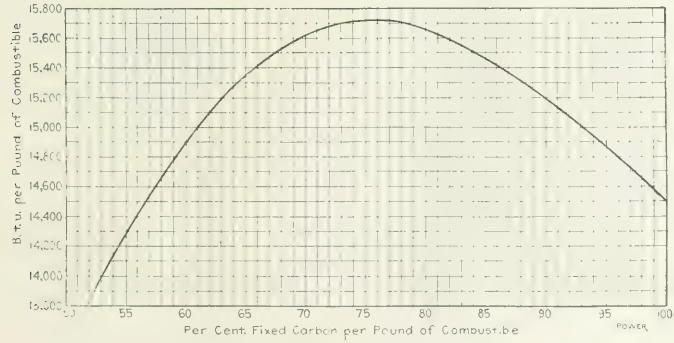


FIG. 2. HEAT VALUE OF COMBUSTIBLE BASED ON PERCENTAGE OF FIXED CARBON CONTAINED

It should be noted that this formula does not hold for anthracites low in volatile matter. Below 12 per cent. of volatile matter this method does not seem to hold true, but it does appear to give results approximately correct for coals having higher than 12 per cent. volatile matter.

The Under-Feed Stoker Co., of Chicago, has worked out a curve, Fig. 2, by means of which the heat value of the coal as received can be determined from the proximate analysis to an accuracy of about 2 per cent. Numerous checks with this curve against the calorimetric determination prove it to be substantially correct.

In this curve the percentage of fixed carbon per pound of combustible is plotted as abscissas, and the B.t.u. per pound of combustible is plotted as ordinates. The fixed carbon as found is recomputed on the basis of a pound of combustible—moisture and ash free coal. The B.t.u. on this curve corresponding to the recomputed value of the fixed carbon in the combustible is then multiplied by the sum of volatile matter and fixed carbon as found. The product is the heat value per pound of coal as received.

Using the previous example the following results are obtained:

Percentage of fixed carbon per pound of combustible equals

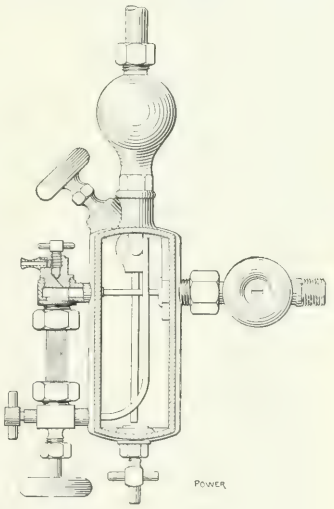
$$\frac{40.63}{74.63} = 54.4 \text{ per cent.}$$

According to the chart in Fig. 2, the heat value of one pound of combustible containing 54.4 per cent. of fixed carbon is 14,215 B.t.u. Then the heat value of one pound of coal containing 74.63 per cent. of such combustible matter equals

14,215 × 0.7463 = 10,609 *B.t.u.*

Lubricator Heating Attachment

A heating attachment for sight lubricators is being manufactured by J. H. Costello, Jr., Scranton, Penn. Its purpose is to permit steam to pass from the steam pipe which leads to the engine or pump, through the oil-discharge pipe of the lubricator and through the heating attachment to the atmosphere. The attachment is screwed into the opening above the sight glass and displaces the customary plug.



LUBRICATOR HEATING ATTACHMENT

This enables the lubricator to freely feed oil, especially when the lubricator is exposed to low temperatures.

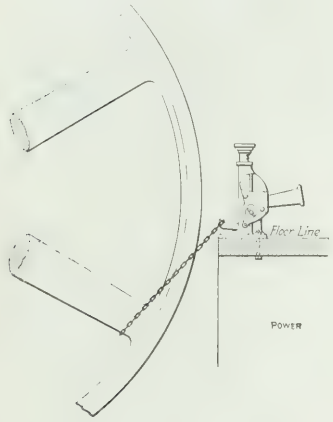
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Engine Jack

A convenient rigging for turning an engine off center, when the wheel is not fitted for a bar, is shown in the illustration.

Any ordinary lever jack will answer, but it should be secured to the floor by a bolt, to keep it from tilting. A chain of the proper length is hooked to one



ENGINE JACK ATTACHED TO FLYWHEEL

of the lower spokes of the wheel, and brought up over the toe of the jack.

Two men can turn an 800-hp. engine off center in a few minutes with this device. I find this jack to be much quicker and more convenient than the chain block used in so many engine rooms.

F. P. READ.

Memphis, Tenn.

Case Hardening

I have never seen the subject of case hardening, or hardening by potash, discussed in these columns. It is of great value to engineers, and those that have small machinery to keep in repair. I find that it increases the life of wrought iron or machine steel to threefold of its ordinary wearing life.

The process is to pulverize yellow prussiate of potash, then heat the part of the machine to be hardened to a red heat, being careful not to burn or blister it. Next roll the part in the potash to get a good coating over the surface, and put it back in the furnace, and let it heat for a few minutes longer. Then take it out and give it another coating and cool it as quickly as possible, and it will acquire a surface so hard that it cannot be filed.

I have tried this on Corliss-engine radial rod pins to good advantage, on crosshead pins and crankpins on small engines. If any reader has a better or simpler process, I would be glad to hear of it.

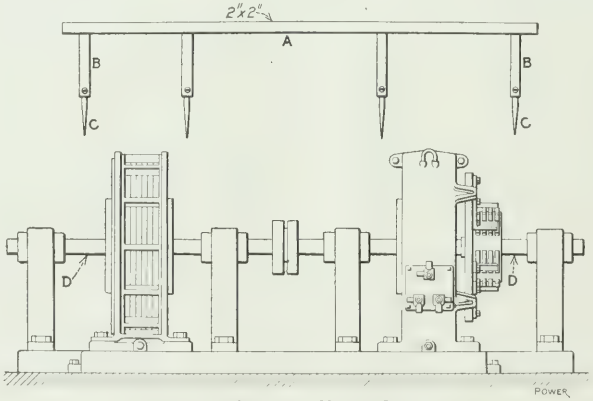
CHARLES MCCURDY.

Richmond, Va.

Template for Lining Shafts

The illustration shows a method of aligning a shaft. A 2x2-in. piece of wood of the length required is shown at *A*; *BB* are 2x2-in. pieces of wood of such a length that the spikes *CC* can rest on the shaft without the piece *A* touching any part of the machine.

The top of the piece *A* should be planed smooth for using a level thereon. The distance of the ends of the spikes *C* to *A* should be equal if the shaft is of the same diameter. By running a cord from the two end pieces *CC*, the center pins can be brought in the same line with reference to *A*, if the shaft is of the same diameter. Should the shaft not be the same diameter, the spikes can be adjusted accordingly.



DEVICE FOR ALIGNING MOTOR SHAFTING

The template is shown as applied to a motor-generator set in which the armatures could not be replaced without moving the frame of one after it had been trued up and leveled with the armatures out.

The center part of the shaft next to the coupling was of smaller diameter than its ends. The diameter of *D* and *D* being equal, *C* and *C* were made the same distance from *A*, and as the diameters of the center of the shaft were equal, but smaller than *D* and *D*, the center pins were made longer than *CC* by one-half the difference of the diameter of the shaft. Placing the template on top of the shaft and a level on the planed side of *A*, the shaft can be leveled in a horizontal plane.

F. J. FORBING.

Ft. Casey, Wash.

Graphite as a Preventative of Scale Formation

Several years ago I had trouble with leaky boiler tubes and badly corroded boilers. The firm had several samples of the feed water analyzed and used several different boiler compounds, each especially prescribed as a remedy for our trouble, but the scale and leaks were steadily getting worse.

A few weeks before I took charge of the plant two boilers had to be entirely retubed; flanges on the steam lines leaked as the compound ate out the gaskets, and the piston-rod packing was troublesome.

As soon as we shut down I had each boiler cleaned, scaled and washed out. In the six months before the shutdown I put in over 200 new tubes, and during the shutdown 27 more.

There were three boilers in a separate battery from the rest, which had given us trouble, as they were driven very hard. I decided to experiment with them and find some means to prevent

the interior corrosion and scale formation. After using soda ash, kerosene and most everything else with little success, I decided to try graphite. The firm ordered some powdered graphite and before the boilers were closed up I put about three quarts in each.

On the fifth morning the engineer on watch informed me that the blowoff valve of one boiler was stopped up and could not be blown down. I tried to clear it several times during the day but could not. I had the boiler shut off and the fire hauled, and on removing the bottom manhole plate a great quantity of scale was found in the blowoff pipe. The graphite had worked in behind the old scale and loosened it up. I made a practice of putting in a small quantity each day with the feed water and found that it prevented further scale from forming and it loosened the old scale.

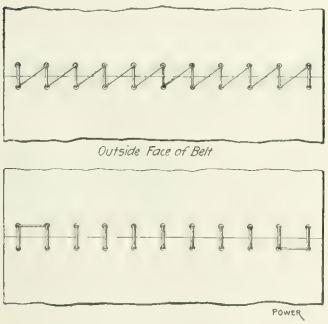
One great advantage in using graphite is that it is insoluble and will not go out of the boiler with the steam; its action is mechanical, not chemical and does not injure the boiler shell or the tubes.

W. V. FORD.

Norwich, Conn.

Belt Lacing

I am a firm believer in wire lacing for nearly all belts. I have charge of six belts, 18 to 24 in. wide, all laced with soft-brass wire; one belt has eight joints in it and some of the lacings have been in for over 10 years. I have had no trouble whatever with any of them. I use wire lacing for lathe belts and for



INSIDE FACE OF BELT

belts running over pulleys as small as 2 in. in diameter.

If the belt is laced properly (and that is half the secret), it will hold against any lacing. After the belt is laced the wire must be driven into the belt until it is flush with its face so that it cannot touch the face of the pulley. The following are the rules we use: Punch holes back from the end about the thickness of the belt; have the holes about ½ in. apart, 9 or 10 to 4 in.; cut off a piece of wire seven times the width of the belt (9 to 10 times the width for double belt); begin at the center, double lace each hole as shown in the accompanying figure; do not let one strand overlap another; pull each strand tight with pliers; double lace the last hole and pass the end through the next inner hole; cut off the end of the wire ½ in. from the belt and bend it over toward the joint; then flatten down the whole joint with a hammer.

J. N. FRIES.

Middleboro, Mass.

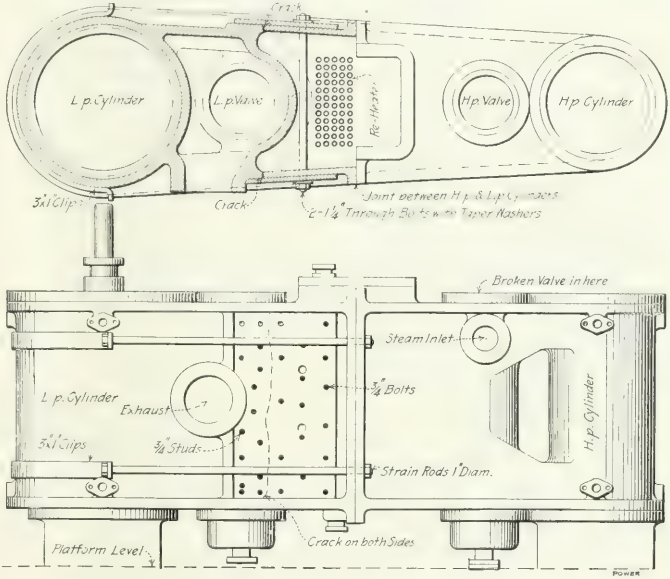
Repair of Cracked Receiver

The main 16 and 34 by 30-in. 400-hp. cross-compound vertical engine was fitted with a Meyer piston valve, and drove a 16-in. gravel pump. One night the outfit was shut down because of a break in the pipe line and as the delivery column was 150 ft. long and ran at a steep angle, the lower sections of the piping and the pump itself were jammed solid with drift. It was difficult to get a start short of opening up the pump and cleaning it out; and the sledge-hammer method used was to get a full head of 160 lb. of steam on the engine, four or five husky helpers on each starting bar, and a stream of water pouring into the pump case through a special cock.

Attention was first centered on the pump, and all hands were surprised to find the air full of flying asbestos and steam. When the fog cleared away, a vertical crack was found in the main receiver between the high-pressure and the low-pressure cylinders. This receiver contained the tube reheater, and was of box shape and much of its area was unstayed, the metal being about 1 in. thick, but the heavy parts were irregularly disposed. There was a crack about 3 ft. long on each side of the receiver body, as shown in the sketch.

The trouble was caused by a ring on the high-pressure main piston valve breaking, jamming and knocking the flange off the valve which admitted the high-steam pressure into the receiver at a time when the engineer's attention was distracted. As he could not see the receiver gage from the starting wheel, he was unaware of the sudden increase in pressure.

The reheater was dismantled, the drain pipes, covers, asbestos, etc., were removed and the drilling of holes started. As the crack was just where vibration was to be expected a steam-tight joint had to be made. Bolts, studs and cap-screws were used and also two 1¼-in. through bolts to draw the sides together. The two ¾-in. plates, 3 ft. wide, 4 ft. long, were made to fit snug between the top and bottom flanges of the receiver and holes were drilled in them to line up with those in the sides of the receiver.



HOW THE RECEIVER WAS REPAIRED

The first joint was made with metallic cement and was a failure. Much disgusted, I had everything ripped out again and remade the joint with a red-lead putty and chopped-hemp mixture, with a liberal allowance of lead wire disposed where it would do the most good. On tightening up the bolts, the plates were tapped evenly with a sledge to bed them, and everything was pulled home snug.

This time it was no experiment and the receiver warmed up without a weep and carried full load without any further trouble.

J. McA. Howden.

Melbourne, Australia.

Strengthening a Cracked Cylinder

The accompanying sketches show two repair jobs of cracked cylinders. Referring to Fig. 1, the crack in the cylinder barrel is shown at *A*; a clamp, *B*, was made and put in place, as shown, while hot. The link strap *C* is made of round iron and is 18 in. long. The iron blocks *DD* are 1 in. thick and fit in the link. One of the blocks must first be secured in place by three bolts. Then put on the second block and drill the bolt-holes ⅛ in. beyond the point scribed on the cylinder through the holes in the block. Next secure the block and heat the link red hot and put it over the blocks as quickly as possible.

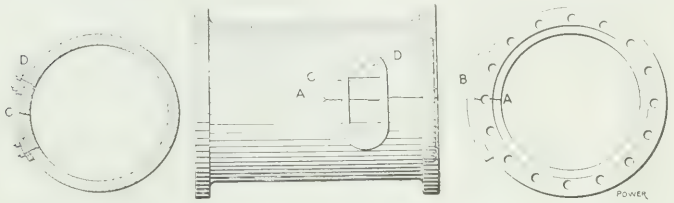


Fig. 1. Cracked Cylinder and Method Employed in Applying the Clamp

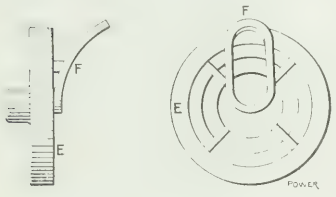


Fig. 2. Machining the Link

In Fig. 2, at *E* and *F* is shown the link in a lathe for machining out the ends which fit around the blocks.

J. G. Koppel.

Montreal, Que.

Purchasing Instruments

To what extent should an operating engineer invest his money for instruments, such as an indicator, calorimeter, portable CO_2 apparatus, etc., when he is working for a company having ample means to purchase anything necessary for economically operating its power plant?

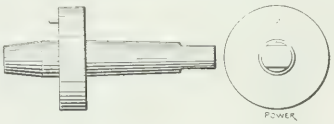
Frank Martin.

College Point, N. Y.

Valve Grinding Tool

It is often necessary to regrind brass pump valves and the easiest method of doing this work is by the use of an air drill. When the valves are cast with projections on top it is an easy matter to apply the power of the drill to them, and if the valves are perfectly smooth on top the tool shown in the sketch is very efficient for this purpose.

In the sketch, an old tapered drill shank with the taper on the upper end, is shown, which fits into the body of the air drill. About 3 in. from the end is a 1½-in. collar, perhaps ⅜ in. thick. This is put on with a driving fit. From the lower side of the collar a 1½-in. pin projects about ⅜ in. The drill shank extends 1 in. below the collar and is ground down so as to fit loosely into the hole in the valve seat ordinarily occupied by the valve stud. With a ⅜-in. drill a small hole is made in the top of each valve just deep enough to engage the small pin. With the valve in position and the drill shank in the air drill, the valve can be quickly and easily ground.



Tool for Grinding Pump Valves

If the pump is small the valves in the lower deck will have to be ground by means of an extension made with a taper at one end and a sleeve at the other.

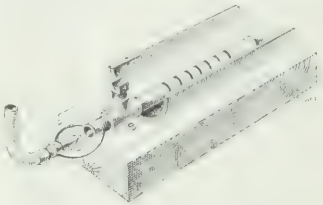
Owen W. Middleton.

Chicago, Ill.

Handy Soldering Iron Heater

The base of the heater is a block of wood about 1½ in. thick by 3½ in. wide and is 8 in. long. Then cut out a piece of sheet iron or heavy tin 5 in. wide and 5¾ in. long; also a piece of heavy sheet asbestos of the same dimensions. The piece of sheet iron is bent into the form of a half circle, the bend being made parallel with the long sides. The piece of asbestos is soaked in water to make it pliable and then pressed against the inside of the half circle of sheet iron, to form a lining to hold the heat. The whole is then attached to the block of wood, with nails, as shown in the illustration. The iron hood comes almost flush on one end of the block, leaving a space on the other end to fasten the tee.

The burner is made out of a ½-in. nipple, 5½ in. long and 15 slots cut half way through it with a hacksaw about ¼ in. apart. One end of the nipple is capped and the other end is screwed into a ½-in. gas tee. It is then fastened to the block with the slots on top.



Soldering Iron Heater

The side opening of the tee is plugged and a notch filed in the top as a rest for the handle of the soldering iron. The frame of an old sprinkler head is screwed into the other end of the tee and serves as a bracket to hold the gas jet, which is a piece of ¾-in. brass tube 2½ in. long and reduced to ⅛ in. at the end next to the burner. The hole in the end of the bracket should be reamed so that the brass tubes will fit snugly. It can then be moved in or out, until it is in the right position relative to the air inlet. If there is no sheet asbestos at hand, asbestos cement or even fireclay will do for the lining.

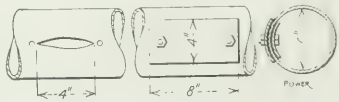
George J. Little.

Passaic, N. J.

Patched Steam Pipe

A long-radius 6-in. steam pipe fractured, and to replace it with a new one would have taken too much time.

The fracture was repaired by sawing out a piece of 6-in. pipe and cutting it into two 4x8-in. pieces. Two ⅜-in. holes were drilled in each 8-in. piece of pipe, as shown, also two holes in the fractured pipe to match. I then cut two pieces of ¼-in. packing to put under the two patches, which were placed on the inside and outside of the fractured pipe. Then the plates were bolted tightly together, as indicated, with ⅜x2-in. bolts.



Patched Steam Pipe

The job necessitated about 30 min. shutdown, and the patch is still tight.

L. H. Wadsworth.

Hooper, Utah.

Wavy Expansion Line

The accompanying diagrams were all taken from a 26x48-in. Corliss engine running at 90 r.p.m. The boiler pressure is 115 lb., gage.

It will be noted that the diagrams in Figs. 1 and 4 have wavy expansion lines.

FIG. 1. EFFECT OF THREE-WAY COCK

FIG. 2. DIAGRAMS TAKEN WITH THREE-WAY COCK REMOVED

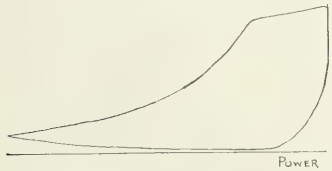


FIG. 3. DIAGRAM TAKEN WITH ONE SIDE PIPE REMOVED; INDICATOR CONNECTED DIRECT

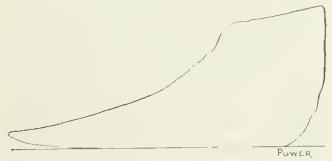


FIG. 4. DIAGRAM TAKEN WITH ONE SIDE PIPE REMOVED

Apparently these are due to the manner in which the indicator is attached. I took two series of diagrams; in one series I used a Crosby indicator and in the other a Lippincott. For corresponding conditions the diagrams from both indicators were exactly alike, so I feel justified in saying that the waves are not due to the indicator.

The diagrams in Fig. 1 were taken with the indicator piped as shown in Fig. 5, a three-way cock being used to control the steam. The diagrams in Fig. 2 were taken with the indicator piped as shown in Fig. 6, a tee and two-way cock taking the place of the three-way cock. The diagram in Fig. 3 from the crank end was taken after removing the side pipe *A*, Fig. 5, and turning the angle valve *B* around to the proper position to carry a short nipple and the indicator. The diagram in Fig. 4 was taken after removing pipe *A*, Fig. 5, and substituting an ell for the three-way cock.

From the foregoing it will be seen that an apparently slight change in the piping arrangements has a marked effect on the expansion line. The boilers which supply this engine prime considerably and the steam is always very wet. Whether this is a contributing condition or not, I cannot say. I would request the opinion of other readers of POWER on this interesting case.

J. W. DICKSON.

Memphis, Tenn.

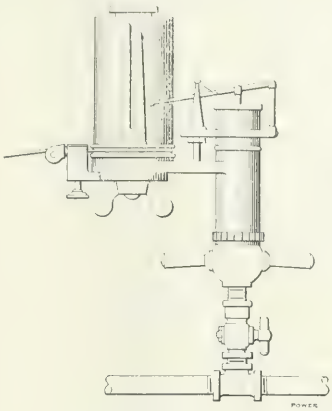


FIG. 6. CONNECTION BY MEANS OF TEE AND TWO-WAY COCK

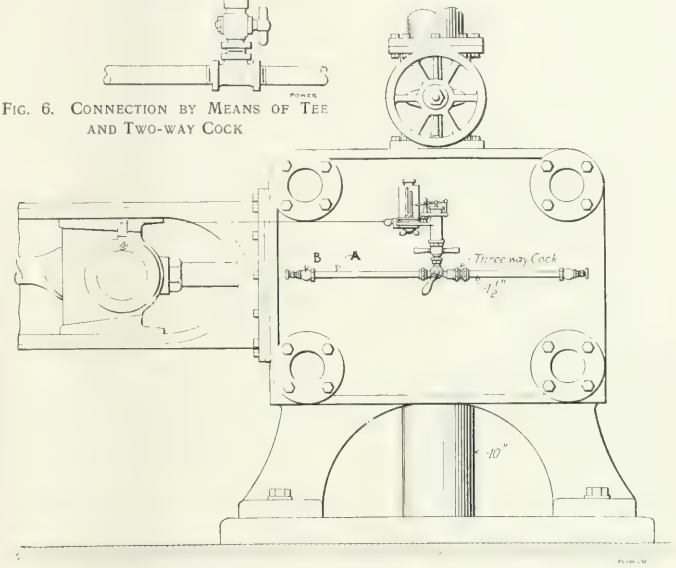


FIG. 5. ARRANGEMENT OF INDICATOR AND PIPING

Where a Record Was Valuable

During a high wind recently about 50 ft. of our 84-ft. stack was blown off. We had a new stack on the ground ready to put up, but the chief engineer was at a loss to know just which was the best way to raise it.

I immediately produced two clippings from my POWER file showing the erection of two different stacks with a good description of the erection of each. Both descriptions were accompanied with photographs taken during the different stages of erecting, which greatly helped the chief.

WALTER B. BROWN.

Deshler, Ohio.

Cleaning A Closed Heater

The ordinary method of cleaning out closed feed-water heaters of the straight water-tube type is to take off the upper head and clean the inside of the tubes with some sort of flue brush. The labor involved in breaking the pipe connections, disconnecting the upper head and boring the tubes of a good-sized heater is a serious item, and as the coating of the inside of the tubes generally consists of oil which has come over with the feed water, the process of removal is quite difficult.

After one experience with a 600-hp. heater I found that by pouring in a bucketful of strong lye after the water had been blown out, then filling it with fresh water to within a few inches of the top, and admitting exhaust steam and letting the solution boil all night, that I had a clean heater the next morning and the labor bill was trivial.

Of course, it is necessary to blow the heater down several times before cutting in so as to prevent foaming boilers.

LINDSAY DUNCAN.

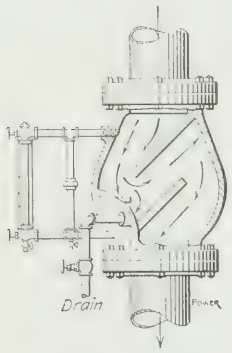
McGill, Nev.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Breakage of Separator Gage-Glasses

If J. W. Dickson and others who have had trouble with gage-glasses breaking will put in a section of pipe between the glass and the separator, they will find



ARRANGEMENT OF PIPING TO PROTECT GAGE GLASS

that fewer glasses will be broken. The accompanying figure shows the manner of constructing the pipe extension.

I have used this arrangement and have found that it holds glasses from 12 to 18 months where formerly they would have to be renewed weekly.

H. L. BURNS.

Caruthersville, Mo.

Lubricator Piping and Lubrication

Replying to E. H. Roberts' letter in the Mar. 12 issue, I say that, in theory, the principle of extending the oil-feed pipe to the center of the steam pipe is correct, but a practical experience of 12 years as an engineer has taught me that there is no material difference in the effect of lubrication whether the oil-feed pipe extends to the center of the steam pipe or ends flush with the inner side.

Where I am employed there are 28 lubricators feeding oil to steam cylinders and of these only one feeds the oil to the center of the steam pipe. This change was made about one year ago on a 400-hp. Corliss engine to determine whether there would be any noticeable effect on the action and wear of the valves, piston and cylinder. No difference has thus far been detected.

In our plant there is also a 200-hp. Corliss engine that has been turning 125 r.p.m., 24 hours per day, for three years without requiring any valve or cylinder repair. The valves and cylinder are in perfect condition today.

The oil is fed into the steam 1 ft. above the throttle valve and the feed pipe only extends flush with the inner side of the pipe.

According to Mr. Roberts, there would soon be a noticeable effect on the action of the valves and piston.

J. W. DICKSON.

Memphis, Tenn.

Valve Locking Devices

In the issue of Mar. 12 are described two methods of locking valves to prevent accidents while working on idle boilers.

A simple method is to remove the valve wheels from the main steam stop valve leading to the idle boiler as well as the blowoff and feed-water valve wheels after closing the valves. This prevents the opening of the valves inadvertently, and a wrench or wheel must be used to cause an accident.

J. J. DEVINE.

Philadelphia, Penn.

Visible and Invisible Leaks

"There are leaks"—how true the story in the foreword for Mar. 5. The engineer who will keep things clean and in good shape shows industry, anyway, which is a good sign, but many smooth-running, clean and neat engines are using from 40 to 60 lb. of steam per horsepower-hour. If this engineer were offered any suggestion, he would be offended; if he were to make a test of his machines, he would become indignant at the machines' own deception.

How many narrow pistons with small wearing surface are cheating; how many light-running square, rectangular and round-plug valves have a stream of steam from two to five thousandths of an inch thick flowing constantly to the atmosphere! Hidden leaks are the power plant's Jonah, and engineers should beware of them.

In many cases, the coal pile is being robbed. Many an engineer's job has been lost through the central station; it employs efficient machines and keeps them under constant observation.

Some funny things happen that never get into print. I told an engineer who had a fine tandem-compound engine that the rings in the low-pressure cylinder were gone. "No," he said; "she runs well and they were put in only a few weeks ago." When they were examined, to satisfy the management, those rings were in a dozen pieces. A dose of water may, some time, put the best set of rings out of commission.

In a large steam plant with the ring system of steam lines so many flange joints and throttle stems were leaking that when they all were packed it was possible to cut out a 72-in. by 18-ft. boiler. The engineer who keeps things clean would have stopped those visible leaks.

Not long since, I inspected a new plant containing return-tubular boilers where cinders and soot had closed off several of the bottom flues.

Much good machinery is poorly looked after, and many steam pumps waste more than they are worth every month. Good heaters are bypassed because of some needed repair or are running with a coating of scale on the tubes so thick that only half of the available heat goes into the water.

Know what a test is, and how to make one; then make one at intervals, keeping a log of the results obtained so as to know what the plant is doing.

I met an engineer recently who said of a fine "long-range" Corliss engine: "I would like it better if it had but the one eccentric; it would be simple, like mine."

When it is known what the apparatus will do, it should be made to do it. It should be known how much steam an engine requires; how much water the boilers will evaporate per pound of coal; how many heat units the coal has, and if it is up to standard.

If it is known that an 11x12-in. engine runs under certain conditions on 30 lb. of steam per horsepower-hour, these facts can be used as a standard. If one can do better, do it, and make an even better standard. We all can do better if we try.

C. R. MCGAHEY.

Baltimore, Md.

What Caused the Rod to Wear?

I think A. E. Kernick's trouble, described in the Feb. 13 issue, is due to chemical action. If the cylinder is not sufficiently oiled inside, the 12 in. of piston rod left inside the cylinder will

rust slightly each day during the 18 hr. the engine is idle. If tallow or other oil containing acid is used the rod will be attacked by the acid. In either case, the chemical action on that part in contact with the open air will not be as great as that inside the cylinder.

I would advise Mr. Kernick to leave the engine standing on the crank-end dead center.

Davidson, Okla. FRED BOONE.

Value of CO_2 Recorder

In looking over POWER of Feb. 13, my attention was attracted to the article of Mr. Pohlman's entitled the "Value of a CO_2 Recorder."

It is stated that the expert was able to obtain 16 per cent. of CO_2 in the flue gases. This seems unusually high and it may not be improbable that the expert was the only man who could obtain that percentage.

Hence, there should be no fault found with firemen if they in turn learned how to "jockey" the CO_2 machine so as to give a good reading if those in authority could be convinced that it is possible to get 16 per cent. On the other hand, I would like to know how it was decided that 11.5 per cent. was a good standard.

In a number of analyses of flue gases made recently I found all the way from 4 to 12 per cent. CO_2 and in no case would it have been possible to get as much as 16 per cent. except by closing the damper.

In the case cited by Mr. Pohlman the fireman cannot be blamed; the chief engineer, in my opinion, is culpable. If in addition to the CO_2 recorder he had provided himself with a good portable CO_2 analyzer and had gone over his boilers once in a while, he might have discovered something that would have paid for the trouble.

A case that came to my notice was in a plant of about the size mentioned by Mr. Pohlman. They had recently installed two water-tube boilers of a well known make which had been in operation perhaps nine months. Upon taking a sample of gas I obtained only 4 per cent. of CO_2, notwithstanding that the chief engineer assured me that the settings of the boilers were perfect. Several analyses were made but none contained over 7 per cent. of CO_2. Later on, when the chief opened the front and back doors we met with a sight that surprised the chief but was expected by me. A low percentage of CO_2 could only mean one thing to me; that is, too much air. Steps were taken at once to repair the furnace.

The plant that cannot be improved by an honest application of either a good CO_2 recorder or CO_2 hand apparatus is indeed an ideal one.

ALFRED FRANKLIN.

Cheltenham, Penn.

Advantage of Thorough Knowledge

I was impressed with J. L. Watson's article, "Lubricator Experience," in the Feb. 6 issue, for it enlightened me as to just why the sight-feed glass fills with oil at times. I had never taken the trouble to figure it out for myself; in fact, I could not have accurately described the construction of a lubricator beforehand, although I had a working knowledge of it.

A thorough knowledge of any piece of apparatus is good to have; it enables one to get the apparatus into trim quickly and easily when any trouble occurs. It is a misfortune to neglect to acquire detailed knowledge of the construction and care of even little things.

The apparent simplicity of a device may sometimes cause a lot of blind experimenting under very trying circumstances when a little previous study and investigation might have made the trouble quite easy to find and remedy.

LLOYD V. BEETS.

Nashville, Tenn.

Lubricator Experience

I would go further than L. J. Watson did on the above subject as regards cleaning and taking care of lubricators. While I was with a firm that habitually bought a cheap grade of oil, we had to take down the lubricators occasionally and give them a boiling out. To do this we had to remove the wooden handles and take out the glasses as they were boiled in a mixture of water and lye.

Finally I hit upon a new way which saved me the trouble of taking them down. I emptied the lubricator and filled it about two-thirds full of coal oil or kerosene, put in the filling plug, turned on the steam, and let it boil for a few minutes; then I gave it a good blowing out. Next I cut up fine a 1-in. cube of laundry soap, put it in the lubricator and filled the latter about two-thirds full of water. I then turned on the steam and let that boil for a few moments, and then gave the lubricator another blowing out.

By using this method, which only took a few minutes, I never had to take a lubricator down, and it was surprising the amount of sediment that came out.

Another way to keep a lubricator clean is to put in a piece of soap just before filling it with oil and when the oil is all fed out, give the lubricator a good blowing out.

As to the use of wrenches on lubricators, I find that the smaller the wrench, the longer the threads on the packing nuts will last. I have seen engineers use 12- and 14-in. wrenches to tighten up the packing nuts, and then wonder why they stripped the threads or twisted off a filling or a drain plug. If a packing nut is tight, it will always leak a little when turning on steam but in a short time it will tighten itself. I never use a wrench on the filling and drain plugs, as these joints are steam tight.

I once had charge of a plant which employed "hunkies" as firemen. One day the head fireman came into the engine room, a 12-in. Stillson wrench in one hand and a drain plug in the other. Showing me the plug, he said, "No good." When I asked him how he did it, he said, "Just tighten him up a little mit de wrench." I have tightened this same plug repeatedly with my hands, but he had to use the largest wrench he could find.

FRED LANGBEIN.

Port Clinton, Ohio.

In the Feb. 6 issue, L. J. Watson states that when the sight-feed glass fills with oil it is necessary to stop the feed, blow it out clean and let it fill with water, before restarting the feed.

I had a ½-gal. lubricator on which it was impossible to keep the sight-feed glass clear over 15 min. at a time, but just the same, it would and did feed itself empty three times during every 10-hour shift, night and day, for 10 years. We always had it blown out at the commencement of each shift.

W. E. STICKNEY.

Prince Albert, Sask.

Pressure in Pump Discharge Pipe

J. C. Hawkins gives, on page 870, in the issue of Dec. 5, 1911, a solution of the pumping problem presented by J. F. Murphy, on page 638, Oct. 24, 1911, in which he reaches the conclusion that nearly five times as much water will be pumped into the higher tank as into the lower one. Eliminating the errors from Mr. Hawkins' calculations, it will be seen that under the conditions given no water will be pumped into the higher tank.

The displacement of the pump, at a piston speed of 100 ft. per minute, is $10^2 \times 0.7854 \times 100 \times 12 \times 2 = 188{,}496$ cu.in. per minute, or 816 gal. per minute. Allowing for slippage, 612 gal. per minute will be delivered to the discharge pipe.

In order to determine whether any water will be discharged into the higher tank, it is necessary to calculate what head must be impressed upon pipe E, to deliver 612 gal. per minute (10.2 gal. per second) into the lower tank.

A flow of 10.2 gal. per second through a 3-in. pipe necessitates a velocity of

$$\frac{10.2 \times 231}{3^2 \times 0.7854} = 333.3 \text{ in. per sec.}$$

or 27.7 ft. per second. The effective head to produce this velocity is found from the formula

$$v^2 = 2gh$$

h being head in feet, and v, velocity in feet per second, from which

$$v = \frac{27.7}{64.32} = 11.9$$

To this velocity head must be added the friction head in the pipe, which can be determined from the formula

$$h' = f \frac{4l}{d} \times \frac{v^2}{2g}$$

in which l is the length and d the diameter of the pipe in feet, and f the coefficient of friction, for which 0.01 is an average value. Since the pressure on the pump due to the hydrostatic head in the 3-in. pipe is given as 20 lb., the length of this pipe may be assumed to be 20 ÷ 0.434 = 46 ft. Substituting these values, the formula becomes

$$h' = 0.01 \times \frac{4 \times 46}{0.25} \times \frac{27.7^2}{64.32} = 63.8 \text{ ft.}$$

The velocity head being 11.9 ft. and the friction head 63.8 ft., the total will be 75.7 ft., so that the water would rise in the 6-in. pipe to a height 75.7 + 46 = 121.7 ft. above the horizontal pipe, and then be nearly 65 ft. below the bottom of the upper tank. Thus the 3-in. pipe is found to be large enough to discharge to the lower tank all the water the pump can deliver at the given speed.

Mr. Hawkins' errors consisted in using 100 r.p.m. for the pump speed, instead of 100 ft. piston speed, and in an incorrect application of the chart for "Flow of Water in Iron Pipes," shown on page 523 for Apr. 23, 1911. This chart gives frictional head per 1000 ft. of pipe, while it was used in this case as though it showed total head, without regard to length of pipe.

C. S. STOUFFER.

Kewanee, Ill.

Clerical Work in Station Reports

Commenting on H. S. Knowlton's article, "Saving Clerical Work in Station Reports," in the Mar. 12 issue, I wish to say that I agree with him that the main duty of an engineer is to keep his plant in good condition and operate it efficiently; yet few men, and particularly those not connected with the engineering or accounting departments of a plant, realize the importance of well kept records.

Mr. Knowlton aptly characterizes the records as part of "the old man's red tape," and that is the feeling held by most men who have to fill them out. The engineer ought to keep these records rather than leave them to the old man.

The series of articles on the "Confessions of an Engineer," appearing in POWER from time to time, give examples of cases where the information contained in such reports would have been valuable to the engineer as well as to the old man.

The use of letters or symbols to indicate the various things that should be recorded is not to be wholly commended as there will probably be more work added in making out the key than will be saved by the use of a single letter instead of several words; of course, where the key is printed upon the form or the record covers a period of perhaps a month, this criticism would not apply.

As all of the occurrences reported by letters will not be the same, and, as in the case of accidents, it is well to have detailed reports so as to guard against their future occurrence or to place the blame where it properly belongs in case of carelessness, it is doubtful if the symbols would prove to be entirely satisfactory.

Leaving the vowels out of most of the words and otherwise condensing them, would appear to be even less satisfactory than the use of symbols. If all engineers were good penmen there would be little reason for objecting, but the probable result would be a misunderstanding of the true meaning, thus defeating the purpose of the records.

The plotting of a curve means the quickest and easiest means of judging results, and especially comparative results; but it is difficult to make use of more than one or two of such curves at a time unless they are all plotted on the same sheet. If it is necessary to take figures from the curves it will be found harder work than to merely copy from a column of figures. Again, there is more liability of making a mistake in putting down readings by making a check mark on cross-section paper than if the figures were written down; also, little, if any, time or labor will be saved as it will be necessary to find the intersection of the proper lines before making the mark.

The suggestion of keeping a handy list of constants ordinarily used is a good one and will save much time and avoid mistakes in arithmetic when results have to be worked out in a hurry.

G. H. MCKELWAY.

Brooklyn, N. Y.

Glass in Hot Box

In the Mar. 5 issue, John Bailey inquired about glass for hot boxes An experience I had some time ago with a 750-hp. engine may be of interest.

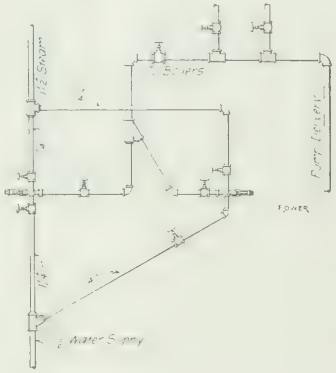
The outboard bearing got hot one evening about 10:30, and cylinder oil was run into it until morning, but it kept at about the same temperature. In the morning the engine was shut down, the cap was taken off and it was found that the babbitt had been started a little. As soon as the cap was taken off, the engine was started up again and some ground glass was put into the box. This did not seem to cool off the box, but I think that it must have smoothed up places where the babbitt had started, for after four hours' work the bearing was running as cool as ever.

CLARENCE R. DAVIS.

East Boston, Mass.

Will the Injector Work?

Referring to J. L. Brouse's drawing in the Mar. 5 issue, I do not consider his method of connecting up two injectors, in accordance with good practice. I assume that the main steam supply to the injectors is only 1¼ in. in size. Since



IMPROVED ARRANGEMENT OF INJECTOR PIPING

each injector requires a 1¼-in. steam supply, I should run at least a 1½-in. supply to the tee where a 1¼-in. branch is taken off for each injector, as he wishes to run both injectors together at times. This also applies to the water-supply pipe.

His method of connecting the delivery pipes together could be improved by using the arrangement shown in the accompanying figure. I believe that one injector alone would deliver more water to the boiler than the two together, connected as they are now.

New York City. THOMAS BAKER.

Cold Air and Leaky Pipe Joints

Mr. Normand's theory of flange contraction, as expressed in the issue of Feb. 13, would be all right if the cold draft blew all around the flange, but most drafts come from one side only, and cause a distortion of the flange that in many cases makes a leak.

Several years ago I was on a steam boat, on which one of the flanges on the main steam pipe came under the ventilator. It was impossible to keep this joint from leaking.

There was no vapor from the leak but hot water came down. By keeping the ventilator turned away from the wind the leak was not so bad. A shield was put over the pipe and there was no more trouble with it.

Chicago, Ill. C. G. HARDEN.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Bare Steam Pipe

What is the loss per hour due to radiation of an uncovered steam pipe 8 in. in diameter and 170 ft. long, if the steam pressure is 120 lb. and the average temperature of the air is 70 deg. F.?

R. O. R.

The temperature of steam at 120 lb. gage pressure is 350 deg. F. The difference between the steam and air is therefore 280 deg. F. For most practical purposes the loss of heat from a bare steam pipe may be taken at 3 B.t.u. per square foot per hour per degree difference in temperature. The actual loss depends on the length and diameter of the pipe, whether vertical or horizontal, and the velocity of the air currents surrounding the pipe. The loss in 1 sq.ft. per hour would be theoretically $3 \times 280 = 840$ B.t.u.; 170 ft. of 8-in. pipe has an external surface of

$$170 \times \frac{8.625}{12} \times 3.1416 = 383.86 \text{ sq ft}$$

therefore the calculated loss of the whole length of pipe would be

$840 \times 383.86 = 322{,}442.4$ *B.t.u. per hour*

Pressure of the Wind

If the wind blows at the rate of 60 miles an hour, what would be its pressure on a flat surface?

E. H. S.

The wind pressure per square foot on a flat surface is about 0.004 times the square of the velocity of the wind in miles per hour. The value of the multiplier varies somewhat according to observations made by different men, being 0.005 according to Smeaton and 0.0029 according to Wipple and Dines. At the rate of 60 miles the pressure on a flat surface would be about $60^2 \times 0.004 = 14.4$ lb. per square foot of surface.

Compression Pressure in Natural-Gas Engines

What compression should a natural-gas engine have to operate to best advantage?

C. W. A.

Most natural-gas engines operate with a compression of about 120 lb. per square inch absolute, but there are several types built to run with pressures, running up to 135 lb. absolute.

Heat Loss in Flue Gas

What is the method of figuring the proportion of heat lost in the gases escaping from a chimney?

M. E. S.

Add 1 to the weight of air used per pound of combustible and multiply the sum by the difference between the temperature of the entering air and that of the flue gases; multiply again by the specific heat of the gases, which may be taken as 0.24 for most purposes. Divide the final product by the heat units per pound of coal. For example, if the temperature of the entering air is 60 deg. F. and that of the flue gases 420 deg. F., the air supply per pound of combustible 12 lb. and the heat value of the coal 13,320 B.t.u. per pound, the heat carried away by the flue gases would be

$$(12 + 1) \times (420 - 60) \times 0.24 = 1123 \text{ B.t.u.}$$

which is

$$\frac{1123}{13{,}200} = 0.085$$

or 8.5 per cent. of the total heat supplied.

Type Metal for Lining Bearings

Will type metal make good bearing lining?

P. K. I.

It will. Type metal is made of lead and antimony, the antimony varying from 18 to 22 per cent.

Air Required for the Combustion of One Pound of Coal

What is a good rule for estimating the amount of air required for the combustion of one pound of coal?

T. H. H.

Multiply the per cent. of carbon in the coal by 11.52. Multiply 34.56 by the difference between the per cent. of hydrogen and the quotient of the per cent. of oxygen divided by 8. Multiply the per cent. of sulphur by 4.32. The sum of all the products will be the theoretical amount of air required in pounds per pound of coal. The rule expressed as a formula is

$$11.52\ C + 34.56\left(H - \frac{O}{8}\right) + 4.32\ S = \text{pounds of air per pound of coal.}$$

Relative Sizes of Boiler and Engine

Can a 50-hp. engine be operated at full load by a 50-hp. boiler?

G. O. S.

It depends upon the type of engine. One boiler horsepower will furnish sufficient steam to develop about 3 hp. in a compound-condensing engine, and only ½ hp. in a small noncondensing engine. Assuming the engine to use 40 lb. of steam per horsepower per hour, the steam pressure to be 90 lb. gage and the temperature of the feed water 200 deg. F., the factor of evaporation would be

$$\frac{1187.2 - (200 - 32)}{970.4} = 1.05$$

The water used by the engine would be $50 \times 40 = 2000$ lb. per hour, or $2000 \times 1.05 = 2100$ lb. from and at 212 deg. F. The boiler horsepower necessary to supply steam to run the engine full load would be

$$\frac{2100}{34.5} = 60.8 \text{ hp}$$

Gas-Engine Valves

Does a gas engine operating with natural gas have valves differently designed from those of an engine using other fuels?

A. F. W.

The design of gas-engine valves does not depend upon the kind of fuel to be used in the engine; it depends on the piston speed and the allowable velocity of gases through the valve ports. Some designers allow a velocity of 5000 ft. per minute past the valves, but more conservative designers put the speed at about 4000 ft. per minute.

Proper Side of a Belt Next to Pulley

Which is the proper side of a belt to put next to the pulley?

B. A. K.

The strongest part of belt leather is near the flesh side, about one-third the way through. It is therefore better to run the hair side on the pulley, in order that the strongest part of the belt may have the least wear. The flesh side will not crack, as the hair side will do, when the belt is old; therefore it is better to crimp the grain than stretch it.

To Aid the German Technical Arts Commission

As announced in POWER of Apr. 9, the Commission of the German Museum of Masterpieces of Natural Sciences and Technical Arts is visiting this country for the purpose of bringing the German Museum at Munich into close touch with the institutions in the United States devoted to the history of technical science.

While Munich has a world-wide reputation for its fine art collections, it is not so well known that it also possesses the finest collection of technical achievements in the whole world embodied in the German Museum. This museum is an establishment of technical art and science, and as such is unique in Europe.

As the committee has only a limited time at its command, it would like such Americans as sympathize with its mission to come forward with a view to facilitating an early communication.

If those who are able to provide facilities to the commission in the execution of its work here, or want to communicate with the members, will send their mail in care of POWER, we will gladly undertake to forward it and render any other assistance possible to make the commission's labors productive of benefit both here and abroad.

Largest Turbine for Chicago

London's newspapers regard as a commercial triumph the fact that C. A. Parsons & Co., of Seaton-on-Tyne, have received an order from the Commonwealth Edison Co., of Chicago, for a turbine which will be the largest in the world. It is divided into a high- and low-pressure portion, the high-pressure being of the single-flow type and the low-pressure element, double-flow; but the design is of the Parsons reaction type throughout and no velocity stages are used. Its sustained capacity is 30,000 kw. and it is guaranteed to produce a kw.-hr. on 11¼ lb. of steam with an initial pressure of 200 lb., superheat of 200 deg. and a vacuum of 28½ in.

Boiler Explosion near Carthage, Mo.

On Apr. 2, a vertical boiler at the mill of the Ida H. mine, near Carthage, Mo., exploded and seriously injured two mill workers. The cause is unknown to the employees, who declare that there was plenty of water in the boiler and that the gages were satisfactorily tested before starting.

Yale Students on Inspection Tour

Fifty-four seniors of the Sheffield Scientific School, Yale University, New Haven, Conn., under charge of Profs. Breckenridge and Roe, recently made a tour of inspection of the largest industrial plants of the country. The photograph, which was taken on Apr. 2, shows the class at the works of the Mesta Machine Co., at West Homestead, Penn.

The average under-graduate, who has never performed actual service in any industry, has practically no idea of the magnitude of the iron and steel manufacture and its allied industries and great benefit has resulted from these inspection tours. They show the student, who has finished the theoretical part of his education, exactly how the manufacture is carried on, particularly as applied to the building of the larger classes of machinery.

GROUP OF STUDENTS FROM SHEFFIELD ENGINEERING SCHOOL OF YALE

New Petition in Rate Discrimination Case

Much speculation centers around a petition which was presented to the Public Service Commission last Monday by Arthur S. Luria, representing the Isolated Plant Publishing Co. and some 400 consumers of Edison current.

Hearings upon the original complaint charging the New York Edison Co. with rate discrimination have been in progress for some months and have had the backing of a number of stationary engineers' organizations. Last Monday, Mr. Bronson, counsel for the complainants, summed up his case, asking that a decision be rendered upon the evidence already submitted. Mr. Luria, however, urged that the new petition be considered along with the existing complaint and the commission ruled in his favor.

While the exact nature of the evidence to be submitted under the new petition has not been disclosed, it is understood that the present classification of rates is to be accepted and the case conducted on definite lines tending toward a reduction in the maximum rate and fixing a limit to the discrimination between wholesale and retail rates.

Much damaging evidence was brought out at the former hearings but a definite procedure was frustrated by the refusal of the defendants to furnish the information asked for by the commission. Supplemented by the existing evidence, a new line of action should bear fruit. Meanwhile the proceedings will be watched with interest.

Newark Industrial Exposition

The publicity managers of the coming industrial exposition to be opened in Newark, N. J., on May 13 to 25, announce that it will aim to be the greatest civic event in the United States this year. It will be opened by President Taft and conducted under the auspices of the Newark Board of Trade.

The exhibitors include the manufacturers of the city's industrial district, and many companies that will be represented are the leaders of their kind in the world.

In conjunction with the preparation for the display there is being conducted a national advertising campaign, designed to give publicity to the exposition and make known to the country the opportunities offered by Newark as a city.

There will also be a large number of live exhibits, where a great variety of modern machinery will be seen.

Further information concerning the exposition can be had by addressing Newark Industrial Exposition, Board of Trade, Newark, N. J.

SOCIETY NOTES

The American Institute of Steam Boiler Inspectors of Boston will hold its annual banquet at the American House on the evening of Apr. 23.

The American Philosophical Society, the Franklin Institute, the American Chemical Society, and the American Gas Institute will hold a symposium in celebration of the centenary of the introduction of gas as an illuminant in Philadelphia, on Apr. 18 and 19. The place of meeting will be the hall of the Franklin Institute.

Elaborate preparations are being made by the local association for the reception of the National Electric Light Association at Seattle, Wash., during its thirty-fifth annual convention on June 10 to 14. Intending visitors are asked to apply to W. J. Grambs, chairman of the hotel committee, as early as possible for their hotel accommodations, thereby assisting the committee in completing its arrangements.

The spring meeting at Cleveland, Ohio, of the American Society of Mechanical Engineers, previously announced for the first week in June, has been changed to May 28 to 31. There are many resident engineers in Cleveland, and they are working to make this convention one of the best in the history of the organization. A complete statement will soon be issued of the papers to be discussed at the professional sessions.

At the twenty-fourth annual convention of the American Boiler Manufacturers' Association, the secretary of the Supplymen's Association was authorized to publish a list of "Boiler Manufacturers in the United States and Canada," which will comprise 100 names verified through mercantile agencies and by direct correspondence. The list will be of interest to manufacturers of tools used in boiler shops, material men, mechanical engineers and boiler buyers. It is arranged with a column in which the credit rating and financial responsibility can be inserted, and may be obtained for $5 by applying to F. B. Slocum, secretary Supplymen's Association, West and Calyer Sts., Brooklyn, N. Y.

Thirty-nine civil-engineering students of the Massachusetts Institute of Technology, who recently visited New York under the direction of Prof. Spofford, were the guests of the Brooklyn Engineers Club on the evening of Apr. 3. An informal talk on "Some European Power Plants" was given the students by George A. Orrok, of the New York Edison Co. He stated that while our power plants may not be the equal of those abroad, in the matter of economy of operation and coal consumption, the plants of the United States are run just as economically. Speaking of the prices paid for the soft coal used in the large power stations, Mr. Orrok said the cost of the fuel in Paris was about $3.60 per ton; in Newcastle from $1.75 to $2.25 per ton, and in London $2.50 per ton. He said the use of hard or anthracite coal in the power stations of the United States had ceased altogether, owing to the prohibitive cost of the fuel.

OBITUARY

Antonio Pacinotti, professor of technological physics at the University of Pisa (Italy) and the original inventor of the multi-segmental commutator, distributed winding and toothed armature core which are fundamental features of all modern direct-current dynamos, died on Mar. 24.

He was born in Pisa on June 17, 1841, and was therefore nearly 71 years old

Antonio Pacinotti

when he died. At an early age he studied what was then known of electricity and magnetism, and in 1860 invented and built the ring-armature direct-current dynamo with a distributed winding and commutator which was independently invented 10 years later by Gramme. The machine did not attract much attention at the time because its future importance was not realized. When he exhibited a model of his invention at the Vienna exposition in 1873, however, recognition of its merit was instantaneous. The Gramme machine invented in 1870 was also exhibited there and as it had been heralded and discussed widely during the preceding three years the scientific and engineering world was in a more appreciative and receptive mental state than when Pacinotti's little machine was built 13 years before.

Pacinotti's leanings were in the direction of research and scientific development rather than practical exploitation, and this accounts for his allowing his splendid achievement to lie almost unknown for so many years while he applied himself to college work and study.

In 1862 he was appointed assistant professor of astronomy at Florence and his work there prevented his carrying out experimental work on a larger scale, which he had planned to do. In 1864 he was made professor of applied physics at Bologna and in 1873 received the same chair at Cagliara.

During the past 30 years, in recognition of Pacinotti's achievements and attainments, scientific bodies and engineering societies and congresses throughout the world bestowed upon him many honors, all of which were received with sincere appreciation and the unaffected modesty which endeared him to all who enjoyed the privilege of personal acquaintanceship with him.

We are indebted to the *Electrical World* for the use of the accompanying portrait and autograph.

PERSONAL

Ray Palmer, a consulting engineer of Chicago, Ill., has been appointed city electrician of Chicago, succeeding William Carroll, who recently resigned. Mr. Palmer is an associate member of the Institute of Electrical Engineers.

Aldis E. Hibner, power engineer of the Livingston Niagara Power Co., Avon, N. Y., has resigned to accept the position of electrical commercial manager of the Empire Gas & Electric Co., of Auburn, N. Y.

F. R. Fortune has been appointed to the newly created position of general sales manager of the Cooper Hewitt Electric Co. Burford Britton succeeds him as district sales manager. The headquarters of both officials will be in the Westinghouse Building, Pittsburg.

J. W. Fraser, assistant chief engineer for the Southern Power Co., and to whom much credit for the present very successful operation of the mammoth generating and transmission system of that company is due, has resigned his position in order to take charge of the building of a complete hydro-electric power plant and transmission system in Australia for the British Westinghouse Electric & Manufacturing Co. The Australian plant will have a capacity of about 100,000 kw. when completed. The first transmission line will be 64 miles long. Mr. Fraser has been with the Southern Power Co. for the past seven years and he is considered to be one of the foremost electrical engineers of the country in the realm of hydro-electric and high-tension plant construction and operation.

Moments with the Ad. Editor

MR. SAMUEL G. MARTIN, chief engineer of the Uxbridge Worsted Company, sends us a copy of POWER for November, 1890, with these remarks:

"Since our friend the advertising editor is so, shall I say, persistent in asking for criticism of the Selling Section of POWER, I will try to soothe his feelings.

"Enclosed are two copies of POWER—one 22 years old and one of current issue. They show the difference plainly enough and the improvement.

"A reader of POWER since 1890, I congratulate you sincerely on the Selling Section."

Thank you, Mr. Martin.

We can think of no more graphical way of showing the improvement in technical advertising, and especially in POWER's advertising, than by reproducing an advertising page of the old days and asking you to compare it with the Selling Section of this issue.

The old ads. are fine examples of what handed trade and technical paper advertising a black eye.

They are mere "cards"—they say nothing and were never changed. They are sedate old tombstones, that's all.

The man who could get the most fancy stunts into the design of his type was the best advertiser.

They pulled some business only because there was nothing better—nothing conspicuously different.

The "general" advertiser, who was spending much more money than the trade paper advertiser, woke up first.

He got real meat into his space and attractiveness into his layout.

But the technical advertiser continued in the old rut long enough to have the outside world ridiculing his efforts.

As a matter of fact, the technical paper publisher was the first to get busy and induce his advertisers to put live "reason why" copy into their ads. It was done as a matter of self-protection—done to make the ads. actually pay.

Now it is no exaggeration to say that some of the best advertising in the country is found in those technical papers which insist that the advertising pages shall be interesting, informative and instructive.

Hence you will find today—in this very issue—that POWER advertising is worth reading.

Things 22 years ago were done differently; power was generated and transmitted differently. You buy and read POWER to know how things are done *now*—this week.

If you want to know *what* they are *done with*, read the ads.

POWER

Vol. 35 NEW YORK, APRIL 23, 1912 No. 17

If You Have a "Kick" Coming, Let Us Have It!

THE publisher of, let us call it, the *Excelsior Banner* every so often would enter the paper's editorial rooms and demand:

"What's wrong with the *Banner?* Had nothing but pats on the back for the past two weeks. I want kicks! Then I know the paper's making a noise, and the readers are interested."

That's us!

We like the "pats," but we want every one of our thirty thousand readers to know that the swift kick planted on that portion of our anatomy which old Mother Nature has wisely cushioned to sustain the shock of a kick, wakes us up and keeps us moving in the forward and upward direction.

We want to know just what you think of the paper; what you like about it; what you dislike; how you think it can be improved.

1. What article most interests you in this issue?
2. Which is most helpful to you in power-plant operation?
3. What change would you suggest to make POWER a better paper?
4. Have you ever written anything for the paper? If not, why?
5. Do you think the articles should be wholly confined to conditions of operating practice?
6. Do you want more reminiscences, humor, anecdotes?
7. Have you availed yourself of the Inquiries of General Interest page? Do you know it is your privilege to ask questions and to get the right answers?
8. What profit have you derived from the "discussions" pages?
9. Has POWER said too little or too much on any one subject?
10. If you are keeping a card index, does the Outline of Topics page answer your requirements?
11. Do you know that we pay for news, facts, ideas?
12. POWER has got many positions for operating engineers. Is your name on our list?
13. What else can you suggest that we have omitted to mention?

We want you to consider POWER *your* paper as well as ours.

In the issue of March 12 we asked you to collaborate with us in gathering news of boiler explosions, flywheel accidents, new power-plant installations, etc., and the prompt response that was made to our appeal strongly inclines us to the belief that as many readers, and even more, will again respond to the inquiries "paneled" in the center of this page.

Give us your frank and honest criticism. Write us a letter telling us just what you think. What you write will be for our instruction, not for publication.

We want to make POWER an even better paper than it now is and, may be, *your* "kick" will do it. This is an open game, so chalk your cue and name your shot. Now kick, and kick hard!

Large Swedish Hydro-Electric Plant

By J. B. Van Brussel

A 100,000-hp. plant employing horizontal turbines running under a head of 100 ft. The plant was built by the Swedish Government at the unusually low figure of $31 per horsepower capacity.

The Swedish government is erecting at Trollhättan a hydro-electric plant which when completed will have a maximum capacity of 100,000 hp., half of this being already installed.

The plant is located on the eastern bank of the Göta River, a stream connecting Lake Vänern, the largest lake in Sweden, with the sea. This lake covers an area of 2180 square miles and the difference between its level and that of the sea is 144 ft., of which 108 ft. is at the Trollhättan Falls. The present flow under low-water conditions is 11,520 cu.ft. per second and at high water 32,400 cu.ft.; the plant is designed to utilize 9000 cu.ft. per second.

FIG. 1. TURBINE HOUSE

The regulating dam across the river is constructed with four openings, separated by granite piers. The two central openings each have a free width of 65½ ft., and are closed by means of bear-trap or roller-dams. The westerly opening is 64 ft. 8 in. wide and is closed by means of five sluice gates. The eastern outlet is 11 ft. 2 in. wide and is fitted with a similar gate. The outlets can be closed for repairs by means of steel needles resting partly against the bridgeway on the pillar, and partly against the sill. This type of construction was chosen on account of the quantities of ice which are carried down the river during the winter. When there is plenty of water, the ice makes its escape through the fully opened central outlets, and with lower water levels it is led away under the partly raised rollers or through the sluice gates.

The intake to the power station is 394 ft. above the dam, and consists of six openings 39 ft. 6 in. broad, separated by brick piers and provided with gates. Under ordinary conditions the speed of the water at the inlet is about 3 ft. 3 in. per second.

The length of the intake canal is 1418 yd., and in the sides of the distribution basin are wooden outlets, to provide for the water flowing through the canal, and thus to prevent flooding the power house in case the majority of the turbine regulators should be simultaneously closed. The water is led in tunnels from these outlets into the river.

There will be eight main turbine units having a maximum capacity of 12,500 hp. and three exciter units. The turbines are of the twin, horizontal Francis type direct-connected to the generators and operate under a head of 100 ft. at a speed of 187.5 r.p.m. The curves, Fig. 9, show the efficiency of one of these turbines as developed on a test.

The smallest interior diameter of the turbine casing is 16½ ft., and the largest diameter is 18 ft. Most parts, especially those exposed to the severest strains are of steel, and each turbine has been tested at a pressure corresponding to a head of 246 ft. of water. Each shaft is made in three parts, connected by couplings and is supported by bearings employing ring lubrication. Two of these bearings, for each machine, are placed against the turbine casing and are accessible for inspection by means of vertical pits. All the bearings are water-cooled and are fitted with thermometers.

In order to obtain a construction combining the greatest possible reliability in working with easy management and durability, all the parts belonging to the governing mechanism have been located outside the turbine-casing so that all the journals can be lubricated and inspected while the machines are in operation.

The construction of these turbines makes it possible to take out each guide-blade separately without causing any serious disturbance beyond the removal of the box belonging to the blade in question and the uncoupling of the small

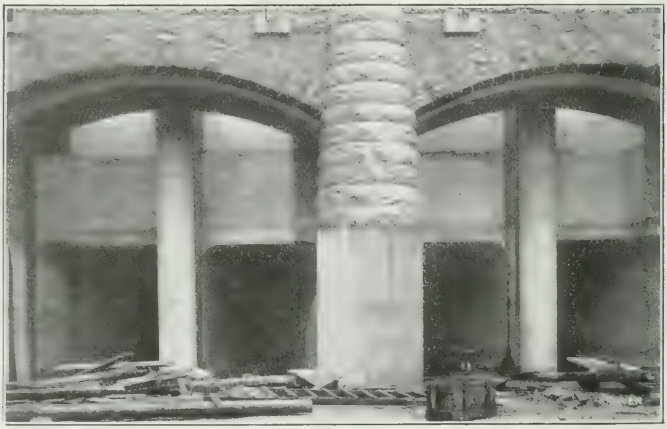


FIG. 2. ENTRANCE TO INTAKE TUNNELS

chain between the crank and the regulator. The governor, which is driven by a belt from the turbine shaft, together with the pressure bell, is placed in a cast-iron casing, which also serves as an oil receptacle. The oil pump is also driven by a belt from the turbine axle.

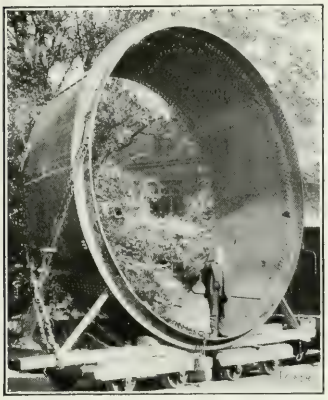


FIG. 3. SECTION OF SUCTION CASING

The brake intended to bring the turbine to a standstill is hydraulic in principle, and is worked from the starting platform. The weight of each of the large turbines complete is about 115 tons.

The generators produce three-phase 25-cycle currents at 10,000 volts. They are entirely encased and draw by suction the cold air through conduits which pass within the walls of the power station and underneath its floor. The air heated in the generators is also led away through conduits; in the winter, however, it is used for warming the station.

For excitation, lighting purposes and power to the auxiliary machines, there is a direct-current installation at 220 volts. This consists of three 500-hp. turbines, each connected direct to a 350-kw. direct-current generator. Connected in parallel with these generators is a storage battery having a capacity of 4800 ampere-hours. The direct-current switchboard is placed on a balcony in the center of the turbine room.

The main switching equipment is located in a separate building about 650 ft. distant from the main station, the cables being led to it through an underground tunnel. In addition to containing the switching equipment this building also contains the transformers, three to each generator, which step up the

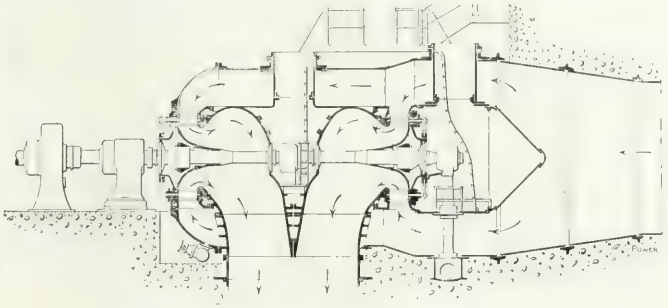


FIG. 4. SECTION THROUGH TURBINE CASING

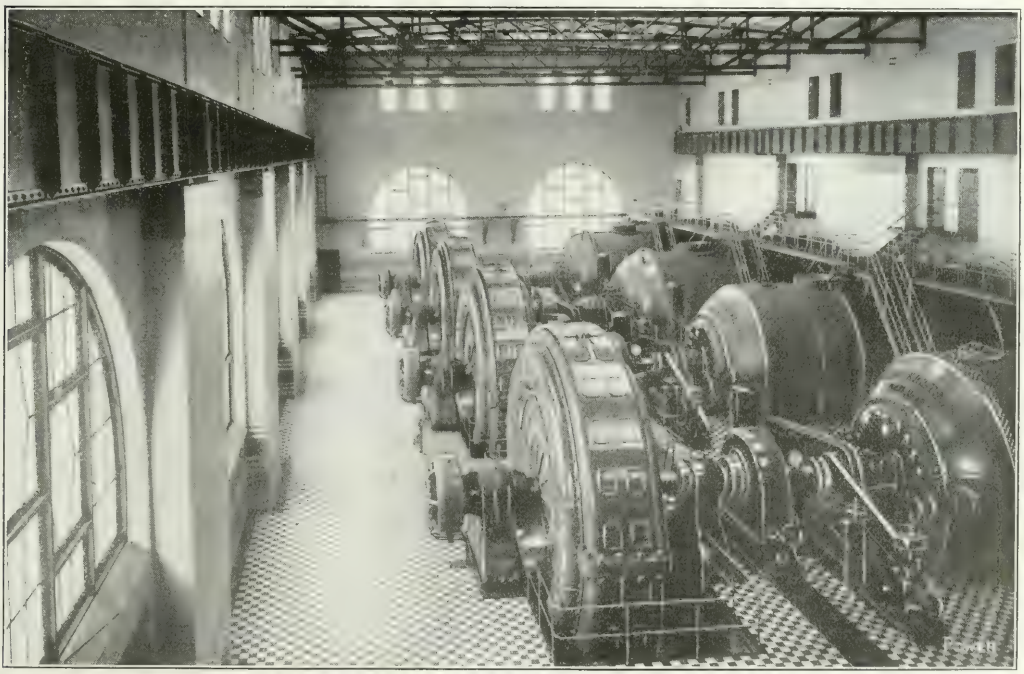


FIG. 5. SHOWING MAIN UNITS

voltage from 10,000 to 50,000 volts. These are oil insulated and water cooled, arrangements being provided for draining off the oil in case of fire. In the center of this building is a room from which the station is controlled. On marble switchboards and desks are placed all the instruments necessary for ascertaining the load distribution of the alternating-current system, as well as all the requisite signal and warning appliances.

The energy is distributed partly at 10,000 volts and partly at 50,000 volts. The long-distance lines are laid out for either the total output of a generator or for half its output; in the latter case they are in pairs. This makes it possible for each generator, with or without transformation of the voltage, to supply energy for a fixed number of lines and to work independently of the other generators; in other words, the installation can be divided into several systems independent of each other.

The machines and the long-distance lines are protected against overload by means of automatic cutout switches. The extra-voltage protection for the long-distance lines consists of water jets for the dispersal of the static charge and of horn-gap lightning arresters with two horns in series with a resistance formed through running water as a rough protection. For smaller discharges horn-gap arresters with oil resistance are provided.

The 50,000-volt current is not supplied direct to the consumers, but is led to large substations belonging to the government. In these stations the energy is stepped down to a more convenient voltage, generally 10,000, and in isolated cases as low as 3000 or 6000 volts. The secondary stations are arranged on the same principle as the switch house.

The cost of the system was unusually low, involving a total expenditure of only $3,132,410, or about $31 per horsepower.

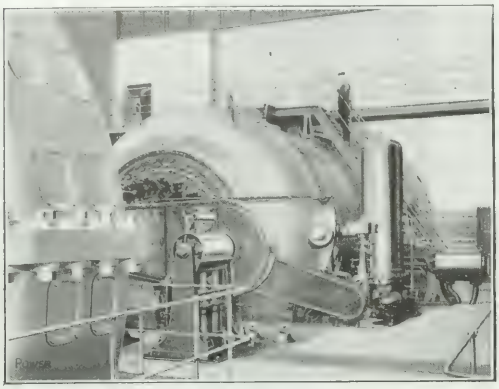


FIG. 6. ONE OF THE MAIN TURBINES SHOWING GOVERNOR

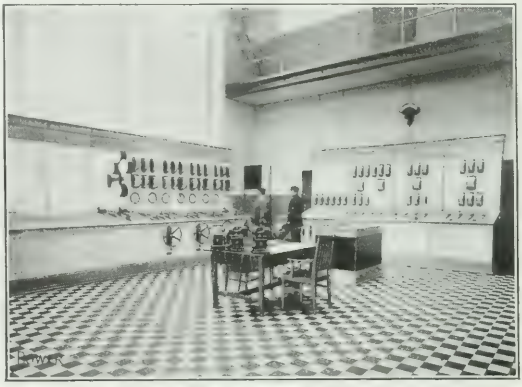


FIG. 7. SWITCHBOARD ROOM

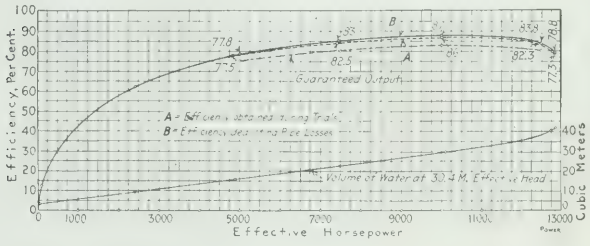


FIG. 9. SHOWING RESULTS OF A TEST ON ONE OF THE TURBINES

FIG. 8. SWITCH HOUSE AND CANAL

Study Questions

The answers to these questions will be given in the issue of Apr. 30.

1. What must be the diameter of a spherical cast-iron safety-valve weight to weigh 64 lb., the weight of the eye-piece being 3 lb.?

2. A noncondensing engine uses 28 lb. of steam per indicated horsepower per hour, the temperature of the feed water 204 deg. F. and the steam pressure 90 lb. gage. What would be the heat efficiency of the engine?

3. What makes a chimney draw?

4. What must be the diameter of the material of an open-link chain to safely carry 34,700 lb.?

5. If a governor ball weighing 12 lb. describes a path 2.5 ft. in diameter and travels at a rate of 282 ft. per minute, what will be the centrifugal force of the balls in pounds?

Notes on Exhaust Steam Accumulators

By Francis H. Davies

Descriptive of several exhaust-steam accumulators of English manufacture and their performance in connection with rolling-mill work.

The utilization of the energy contained in the exhaust steam of a reciprocating engine by means of a specially designed low-pressure turbine is not, as might be supposed, a new idea, the combination having formed the subject of a patent taken out some 70 years ago. It has remained, however, for the engineers of today to perfect the suggestion and to carry it into practice. The means taken to this end are of much interest, particularly where they relate to intermittently running engines such as those operating steam hammers, rolling mills, etc.

It is obvious that in ordinary practice the supply of exhaust steam from engines of this nature will vary considerably in quantity; furthermore, where it is desired to use the combined exhaust of several engines, each running more or less intermittently, the amount of steam available and the pressure fluctuations may vary over a still wider range.

System of Storage

This difficulty can only be met by a system of storage designed to absorb the surplus heat of the exhaust steam during periods of oversupply and to return it with a minimum loss when the supply falls below the demand of the turbine.

Several accumulators have been designed to produce this regenerative effect. One of the earliest is the scrap-metal accumulator which, although comparatively inefficient, is useful for small plants and still finds some employment. It consists of a cylindrical shell (generally an old boiler) the inside of which is packed with condemned rails stacked on top of one another parallel to the length of the shell. The exhaust steam enters at one end and leaves at the other, and the regenerative effect is produced by the condensed water lying in the interstices between the rails.

An important objection to this type of accumulator is the number and the consequent cost of the old rails required. For instance, a 24x6-foot shell will take 50 tons of rails, and for the output which such an accumulator is capable of handling, the space required is large. One of this size and type has been installed in connection with a 175-horsepower Rateau turbine, the load upon which is very erratic.

Rateau Accumulator

Professor Rateau has been extremely active in the development of the steam turbine, and among many other improvements for which he is responsible is the Rateau accumulator, which is illustrated diagrammatically in Fig. 1. The exhaust steam enters at the branch pipe, as shown, and from there passes to the oval tubes which are arranged in two or more pairs. These tubes are pierced on their adjacent sides about 12 inches below the water level with rows of small holes through which the steam flows to the water in the shell, rising and circulating in the direction indicated by the arrows. Above each pair of tubes there is a baffle plate, the function of which is to prevent priming, which would otherwise result from water being thrown up into the steam space by the bursting of steam bubbles on the surface. The level of the water in the shell is kept constant by a ball float valve controlling the intake on the right, and the blowoff valve on the top is set to relieve the accumulator, should the pressure rise materially above normal.

Generally speaking, this type of accumulator in the size normally installed will regenerate a sufficient supply of steam for the turbine to permit the engine being stopped for about four minutes, but if the interval is longer than this it becomes necessary to admit live steam. This is done through the agency of a reducing valve which is set to admit live steam automatically to the shell at atmospheric pressure. The valve is controlled by the pressure in the accumulator, and by this means the installation is rendered free from all risk of stoppage through temporary failure of the exhaust-steam supply.

The diagrams shown in Fig. 2 are particularly interesting, contrasting as they do the effect produced with an empty receiver and one containing the necessary body of water. The test of which these diagrams are the result was made with a Rateau accumulator under the following conditions: The empty shell had a capacity of 7000 cubic feet, and into this was led the exhaust from a rolling-mill engine having two 40-inch cylinders and a 5-foot stroke. The turbine used 20,500 pounds of exhaust steam per hour at full load. In the case of the empty accumulator, which was then merely acting as a receiver, the pressure fluctuations were extreme, as shown in the upper diagram, and were such as to render steady running of the turbine impossible. On the other hand, with water standing at a depth of 11 inches above the holes in the oval pipes of the accumulator and at a temperature of 110 degrees Fahrenheit the pressure variation was greatly improved, showing in no case a fluctuation exceeding ¾ pound. It should also be noticed that, although the rolling-mill engine was stopped for 1¼ minutes after the second minute line of the chart, the drop in pressure was very gradual and negligible

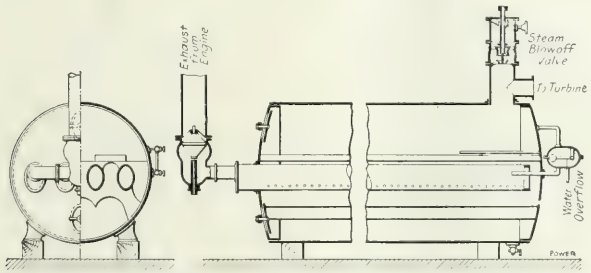


Fig. 1. Rateau Accumulator

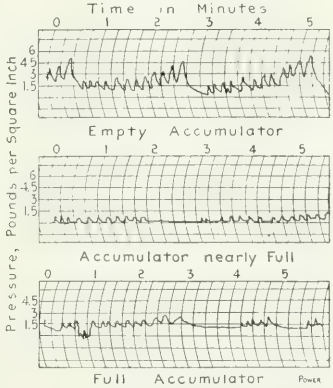


Fig. 2. Charts Showing Effect of Exhaust Steam Accumulator

in amount. The bottom chart was taken with a water level of 13 inches above the holes and at a temperature of 212 degrees Fahrenheit. It will be seen that the pressure is somewhat higher than before, the increased temperature of the water having slightly reduced the condensing effect on the exhaust steam.

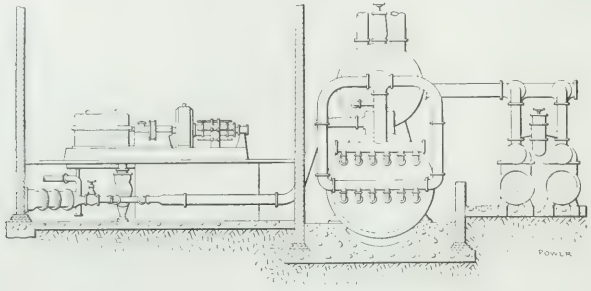


FIG. 3. LAYOUT OF EXHAUST STEAM TURBINE PLANT

LAYOUT OF EXHAUST-STEAM TURBINES

Fig. 3 shows the layout of an exhaust-steam turbine installation in a steel works, and gives a general idea of the usual arrangement. In this plant the engines which deliver about 41,000 pounds of steam per hour after deducting pipe condensation, etc., exhaust into the accumulator, and are made up of the following units: one two cylinder cogging engine having 40-inch cylinders and a 5-foot stroke; one finishing engine, with a 42-inch cylinder and a 5-foot stroke; two small mill engines and one 10-ton and one 4-ton steam hammer. The Rateau accumulator is shown surmounted by a shell receiver, the object of which is to reduce the shock of the incoming exhaust steam. The extra inlets on the top of the receiver are for connection to the rolling-mill engines. Leaving the accumulator, the steam passes through a large main to the turbines, which are each of 450 kilowatts capacity, and these in their turn exhaust to a barometric jet condenser, not shown in the sketch. At the far end of the turbines a high-pressure steam main is brought into the engine room, and this supplies low-pressure live steam to the turbines through a reducing valve at such times as the main engines are shut down for roll-changing, etc.

The accumulator is designed to deal with engine stoppages of 45 seconds when both turbines are working at full load, and it is interesting to note that after the main engines are shut off, one turbine has run on the steam delivered from the accumulator alone for six minutes at a load of 390 kilowatts, which dropped to 125 kilowatts at the end of nine minutes.

Another type of regenerative heat accumulator, manufactured by the Cruse Controllable Superheater Company, is illustrated in Fig. 4. The underlying principle is that the water, instead of lying in a mass, should be broken up into a fine shower in order to secure intimate contact with the exhaust steam and to keep the size of the accumulator down to a minimum. The exhaust steam enters at the bottom of the vessel *A* and emerges at the top on its way to the turbine. In its passage through the vessel it is met by the falling shower of water, the action of which alternates between heat absorption during periods of exhaust-steam supply and heat emission when the steam is cut off.

The heat-storage vessel *B* is originally filled with water from the main by the circulating pump, which then forces it round in a circuit through the two vessels. In its passage upward the exhaust steam passes through holes in the trays which are saw-edged, and at the top, in the condensing chamber, flows through the perforated baffle plates, the duty of which is to rid the steam of entrained water. The storage vessel *B* is always kept full, receiving its supply through the well chamber at the bottom, which insures an even distribution and prevents coning or boring of the water. The accumulator is fitted with an auxiliary live-steam supply, and it is usual to install an oil separator between the engine and the steam inlet.

SCHWARZ ACCUMULATOR

Another type of accumulator, the Schwarz, is shown in Fig. 5. Its principle is similar to that of the one previously described but it possesses some interesting and distinctive features. The exhaust steam, after passing through an oil separator, enters the accumulator at the upper inlet on the right-hand side. It then flows downward through a duct formed by a partition in the outer cas-

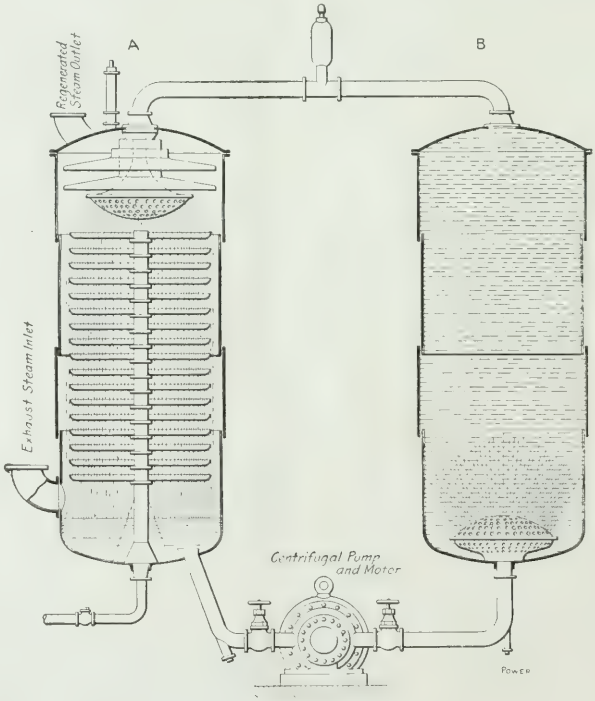


FIG. 4. CRUSE ACCUMULATOR

ing, and changing its direction at the bottom passes upward through the drain chambers and out to the turbine at the top. The interior arrangements shown consist of a number of chambers with perforated bottoms on which stand irrigation tubes. Under each of these cham-

bers are placed gratings, which spread the water forced round by the circulating pump and turn it into a shower which meets the steam and mixes intimately with it. The change of heat is rapid and efficient, owing to the close contact of the water and steam.

When an excess of steam is exhausted into the accumulator the pressure rises; but the difference in temperature between the steam and water is equalized by part of the steam being condensed; the pressure therefore falls and the water acquires a further store of heat. When, on the other hand, the supply of exhaust steam falls short the pressure drops proportionately; but as the temperature of the water is then higher than that of the incoming steam the water evaporates, and by supplying steam keeps

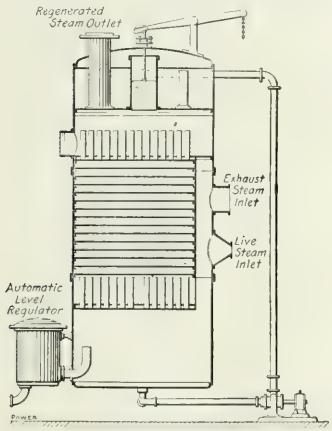


FIG. 5. SCHWARZ ACCUMULATOR

up the pressure. The accumulator is fitted with an automatic live-steam valve for maintaining the pressure when the quantity of exhaust steam falls short. There is also a safety valve for dealing with overpressure and an automatic draining apparatus for removing the surplus water of condensation.

An interesting feature of this type of accumulator is the method by which the volume of water is regulated in accordance with the requirements of the varying volume of steam. The action depends upon the pressure in the accumulator. Should this rise above a predetermined limit, the valve shown in the top of the steam chamber opens automatically and the water stored in the upper chamber flows into the lower until the pressure is equalized. This is in itself a material advantage, but it has the additional virtue of reducing to a minimum the power required by the circulating pump.

Thirty new electrical enterprises, including both hydro-electric and steam power, are contemplated in the United Kingdom.

To Engineers of Isolated Plants

By Henry D. Jackson

Much has been written recently regarding the central station taking over so many isolated plants, and numerous engineers have said that an isolated plant could not compete with a central station, and *vice versa.*

The situation will not be cleared up until the isolated-plant engineers begin the keeping of accurate power-cost records. There are a large number of isolated plants in which the engineers are given every opportunity to obtain accurate and reliable power-cost figures, and in many cases engineers take advantage of their opportunity. Where this is not done it is but natural that the plant owner should consider that his plant is not doing as well as it might under purchased power, because the sales agent of the power company can hand him figures concerning his power costs which he is absolutely unable to refute, owing to the lack of interest taken in this matter by his engineer.

In many plants no facilities are given to engineers for obtaining records, and the engineer frequently feels that records are of no avail. There is, however, an opportunity open to the engineer in all of the isolated plants to educate the owner or manager to the value of records, and no plant is so small that it will not pay the engineer to keep records if only for his own satisfaction. It may be that these records are not even approximately exact, but they can be made comparative, and show from month to month or week to week what the comparative cost of power has been.

It is not absolutely necessary to weigh the water or the coal to get comparative records. If the engineer finds out approximately how much water he evaporates for a certain quantity of coal every day, and notes what machinery is in operation, keeping an accurate record of the amount of oil, waste, supplies, etc., used, he can hand in from day to day records which may be comparative. Then it is natural to assume that the owner or manager will want to know what these figures represent, thus giving the engineer a chance to bring forward arguments showing the necessity for scales for weighing the coal, some method of keeping track of the water. Having started in a small way and proving his case—which he may readily do by showing that during a certain period coal having a certain price would evaporate only a certain amount of water, whereas other coal at a higher price would evaporate more water in proportion to this price than the low-priced coal, thereby proving the value of the high-priced coal—the owner will see the value of such records and perhaps ask if there is not an opportunity for keeping still more records and with more accuracy.

It is also worth while for the engineer in the small plants who may not have an indicator to get some friend or associate who may have an indicator to indicate his engines now and then, thus determining what is the condition of the valves and the load. By taking indicator diagrams under various conditions of load, the engineer will be enabled to obtain an approximate idea as to what the load of his engine will be at other times by finding out what machinery is in operation, and enable him to at least roughly figure out the amount of coal and water used per horsepower-hour during the day. He will then gradually accumulate information that will aid him in refuting the claims of the central-station men.

It would also be a comparatively easy matter for the engineer to obtain fairly accurate figures regarding the cost of the engines, the boilers and the plant, so as to determine the fixed charges on the plant. He must know the labor charges; and these, with the fixed charges and cost of coal, water and supplies, will give the total cost of power. Then, knowing the power required, he can give the cost per horsepower-hour, which can be readily reduced to cost per kilowatt-hour in order to make a comparison with the cost of purchased power.

In the case of purchasing power the total power supplied at the switchboard must be figured; that is, say, if a plant requires a certain power at the motors, there is always a loss between the switchboard and the motors, depending upon the size of the motors, this being the loss of power in converting from electric into mechanical power. This will vary from 70 to 85 per cent., according to the size and the type of the motor.

To this power cost should also be added the additional interest, maintenance and depreciation charges due to the motor installation, and from this should be taken the interest on whatever may be obtained from the sale of the discarded apparatus. It should be noted, however, that in making the change the interest on the cost of discarded apparatus, minus the amount received for it, will go on just the same during purchased power, and, therefore, should be added to it.

The whole situation is to a large extent in the hands of the isolated-plant engineer. If he wants to hold his job, it is up to him to show that he is worth it; if he is not, he is bound to lose his job. By showing a live interest in the plant, the engineer can prove to the manufacturer that he is quite as important as any other man in his employ covering a department of the same value, and he will gradually gain the confidence of his employer, get an increased salary and rise in his vocation.

Management of Steam Power Plants

Suggestions as to the maintenance and economical operation of steam plants.

The requisites of a competent engineer and the latter's relation to the employer.

Under the auspices of the general committee of the combined associations of Manhattan and Bronx, N. A. S. E., a very successful meeting was held at the Broadway Central Hotel on the evening of Apr. 3. The meeting formed part of a general program being carried out by the committee for interesting the employer or manager in matters pertaining to the plant operation and for bringing him into closer touch with the engineer. That the employers have responded enthusiastically to this idea was evinced by their large representation at the meeting.

The speaker of the evening was Prof. E. V. Lallier, who talked upon "The Management of Steam Power Plants." Without entering into technicalities, he treated the subject from both the physical and the business aspects, pointing out how economy is dependent both upon the physical condition of the apparatus and upon its intelligent and efficient operation. While a plant should not be hampered by shortsighted finance, on the other hand, it should not be carelessly granted expenditures, but only after careful consideration has shown that such expenditures may be expected to produce the desired results.

It was pointed out that an engineer besides being practical, must be to a certain extent theoretical, so as to be capable of reasoning out engineering problems and applying the results to the plant in his charge. In addition to this he should possess business ability, be familiar with costs and capable of analyzing the various branches of his department with regard to their relations to each other, so as to keep accurate records and make complete reports. In this connection Prof. Lallier drew attention to the necessity for the engineer, who is held responsible for the efficiency of the plant, to know the cost of supplies and to be consulted as to the quality of the material purchased, so that the employer may not only profit by the engineer's advice and experience but that the latter may operate his plant more intelligently. Unfortunately, supplies are frequently purchased by some office man wholly upon the merits of the price quoted without regard to their fitness for the service required.

Concerning the physical features of the plant itself, Prof. Lallier's remarks were in part as follows:

The apparatus in too many plants is installed without due regard to accessibility. For instance, when a pump rod is to be removed, instead of meaning an hour or two of work, it necessitates moving the pump, breaking the connections and involving much unnecessary expense. Again, many boilers are placed so close to the ceiling that any repairs to the piping or valves above them cost at least twice as much as they should, due to working in a restricted space.

Good ventilation and plenty of light are also necessary. These are not only aids to health, but a light plant is usually kept clean.

Another necessity is a well ordered storeroom which as a time-saver will more than pay for the space utilized.

The boilers should be of such size as to readily carry the normal load and still have some reserve capacity. A spare boiler should be provided, not only to permit of the usual cleaning but also so that the regular operation of the plant will not be interfered with, should a breakdown occur. Where the load is variable the water-tube type of boiler is perhaps preferable on account of the readiness with which it responds to an increased demand for steam, but for the smaller plant, or one having a steady load, the fire-tube type is usually best fitted, for it requires less constant supervision.

Manual regulation of the draft should not be permitted, as this is necessarily irregular in application and is wasteful of fuel. With an automatic damper regulator the air supply is maintained within very close limits.

Too much care cannot be given to the condition of the feed valves, safety valves, steam gages, and particularly the blowoff valves. The latter are often placed in a more or less inaccessible place and an undiscovered leak will often prove an expensive matter.

Another prolific cause of waste is leaky traps; such a condition permitting a small but continuous flow of steam which is difficult to detect except by constant vigilance and checking up the results.

Regarding the accumulation of scale in boilers, it may be remarked that a layer $\frac{1}{16}$ in. thick may cause a loss as high as 20 per cent. of the fuel and a layer $\frac{1}{8}$ in. thick, a loss of nearly 30 per cent. Scale to some extent is an unavoidable evil, but too much of it is not unavoidable.

The burning of fuel is a very important matter, as the heat losses, comparatively large in any case, may easily be increased by improper firing, and by grates and furnaces unsuited to the work. The furnace should have ample combustion space and should be able to burn the maximum amount of fuel under unfavorable conditions of draft. The grates must be placed the correct distance from the boiler to care for the kind of fuel used and should have air spaces proportioned to the quality of the coal.

For large sizes of anthracite almost any average grate and a fair draft will serve, but, of course, intelligent firing is required; the fire must be kept of an even thickness and watched to see that no thin or dead spots occur. If the bed of coal is too thin, an excessive amount of air will pass through, whereas, if it is too thick, some of the carbon will be burned to carbon monoxide only, instead of to carbon dioxide, thus involving a waste of heat. With the finer sizes of anthracite a better draft is required and a thinner fire must be carried. This requires closer attention and more frequent cleaning.

It may be desirable to burn bituminous coal, but with the ordinary methods of hand firing, in addition to the fact that in New York City most of the furnaces are built for anthracite, it is difficult to obtain economy without exercising care in handling the fuel. In some plants the hard and soft coals are mixed, but with varying results, due largely to the methods of firing.

Another important factor affecting the operation of a plant is the proper insulation of pipes. For instance, recently a steam pipe 60 ft. long was subjected to a test and the steam was found to contain 31 per cent. of moisture; after covering with an efficient heat-insulating material this moisture was reduced to 3.6 per cent.

Various materials are available for this purpose, among the best of which are hair felt, slag wool, magnesia and asbestos. Hair felt, while an excellent nonconductor, must be protected from actual contact with highly heated pipes to prevent it from charring. On the other hand, slag wool has the advantage of being fireproof. A mixture with asbestos as a base is largely used with good effect and is supplied in convenient form for application. Water should not be permitted to drip on the pipe covering, neither should a leak, however small, be allowed to continue, for in addition to the loss due to the escaping steam, a wet covering readily becomes a very poor insulator of heat.

A word may be said in regard to reclaiming oil. Cylinder oil, such as may be separated from the exhaust steam, is valueless as it holds in suspension finely divided particles of hard carbon which

will cause injury to any wearing surface, also its vitality, so to speak, has been injured by the heat to which it has been subjected. On the other hand, the oil which has run through the comparatively cool bearings may be reclaimed and filtered in order to cleanse it of any dirt, and mixed with some fresh oil it may be used again.

Supplies and accessories should be purchased with intelligence and discrimination. Some time ago the daily papers had much to say about a five-foot book shelf of literature; the speaker believed that every engineer should have in his engine room a five-foot shelf of catalogs covering subjects pertaining to his calling and that he should become familiar with their contents. Many catalogs are extremely valuable on account of the rules and formulas they contain, also the descriptions of the articles sold and instructions for their use.

When anything for the plant is required, the engineer should ascertain as to the articles best suited to his requirements; he should then obtain the best prices and discounts possible. If he is not already familiar with the particular article he should visit some plant in which it is used, after which the purchase should depend strictly upon the merits of the article selected, for the price is not always an indication of its value for a given purpose.

A neat and compact method of keeping track of the cost of the various materials purchased is a small card index. The very fact of having a record of the supplies will enable the engineer to learn what kind and quantities will be required for a month to come; consequently he may send in a requisition covering everything required for the coming month and thereby avoid much delay and friction.

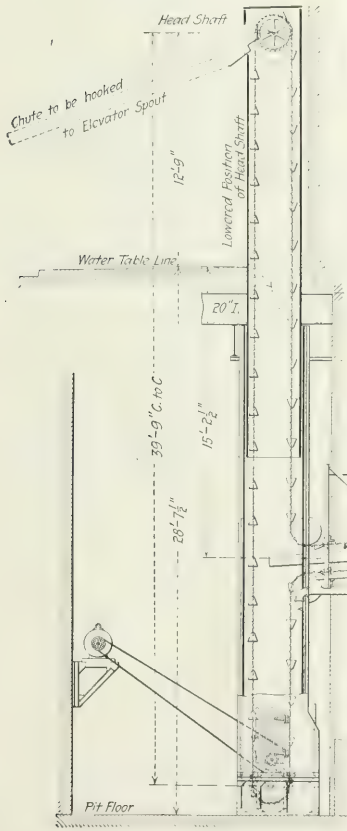


Fig. 2. Ash Elevator in Detail

Jeffrey Ash Elevator

One of the problems confronting engineers of office buildings, hotels, etc., in city districts is the removal of the ash refuse from the boiler plant. Hoisting ashes in cans through a manhole in the sidewalk by means of makeshift devices is slow, laborious work and is not liable to improve the temper of the tenants or guests.

In Fig. 1 is shown a Jeffrey telescopic ash elevator which is installed at the Astor Hotel, New York City. The photograph shows the elevator raised above the sidewalk, also the method of discharging the ashes into the ash wagon drawn up at the curbing. This elevator has a capacity of 7 tons per hour. Fig. 2 shows details of the elevator which contains 160 ft. of chain used in two equal strands, and 46 malleable-iron buckets each 6x10 in. in size.

Fig. 1. Chute in Position to Deliver Ash to Waiting Wagon

When ashes are to be taken from the boiler room, which in this instance is by means of an overhead trolley, they are discharged into a hopper which is located at the lower portion of Fig. 2. The ashes are brought down through a passageway and are then elevated by the buckets to the ash-discharge chute and carted away.

When the elevator is not in use the buckets and chain are drawn to the horizontal position shown in Fig. 2, but when ashes are to be elevated, which is usually done late at night or early in the morning, the head of the elevator is hoisted to its extended position from the point shown by the dotted circle just below the street level. The horizontal chain and buckets are drawn into the shaft until the compensating pulley assumes the position shown by the dotted circle between the horizontal buckets. The illustration indicates the two extreme positions of the elevator when in and out of use. When the chute is not in use, it is droped beside the elevator casing.

Bending Sand-Filled Pipe

By J. E. Terman

Fred was a good blacksmith, but he lacked foresight. He worked for a master mechanic who had advanced notions in regard to piping, and who insisted that all elbows be done away with as far as possible. Therefore bent pipe had to be used in their stead, and the pipe-bending jobs fell to the blacksmith.

On the large pipes, Fred would always make a good job, for he would take many short heats and make a nice, smooth bend, but on the small-sized pipe, he got impatient and would try to bend it too quickly; the result was that the pipe was flat on the curve or otherwise deformed.

One day the master mechanic was guying Fred about his pipe bends, and told him that it was customary to fill the pipe with sand to prevent it being flattened while being bent. The blacksmith thought this a capital idea, and the next time a 2-in. pipe was to be bent, he told his trusty helper to fill it with sand.

It happened that a sandy road ran near the shop, and the helper took the piece of pipe, which was about 12 ft. long, out to this road and rammed it full of wet sand. The job was pronounced satisfactory and the pipe was put on the forge to heat. While the helper worked, Fred stood in the doorway whistling his favorite tune and wondering why he had never thought of so simple a thing as sand, himself.

Suddenly there was a bang! and the pipe exploded. The tightly packed wet sand in the pipe had prevented the escape of the steam formed at the heated section.

The master mechanic thought it a great joke and told Fred that he ought to have had sense enough to use dry sand, and advised its use in the future. However, Fred had learned his lesson and thereafter refused to bend a piece of pipe that he could not look through.

Furnace for Burning Low Grade Fuel*

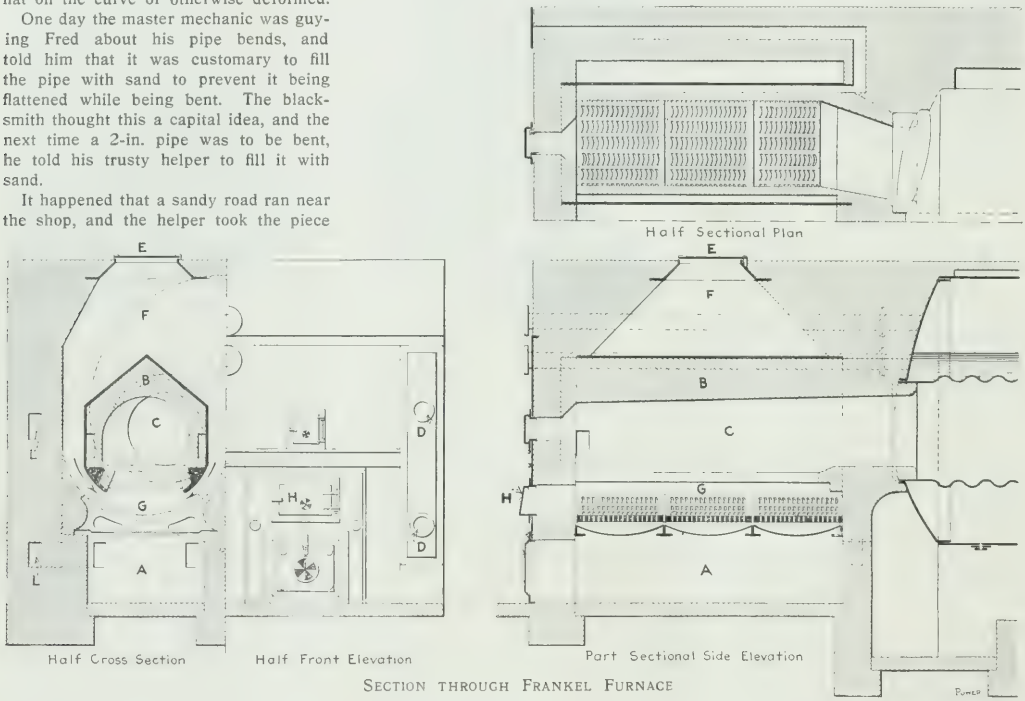
Good combustion in a furnace may be considered as dependent mainly upon the following factors:

1. The stoking must be regular; no part of the grate should be bare, and, as far as possible, an even layer of coal should be distributed over the grate.
2. Air for combustion must be supplied in the proper quantities.
3. The air must mix with the gases as intimately as possible.
4. A sufficiently high temperature must be produced and maintained continuously.

A furnace which apparently complies with these requirements and permits the economical use of low-grade coal is the so called Fränkel furnace, herein illustrated. Coal is fed from the top through the charging door *E* into the fuel space *F*. Here it surrounds the brickwork *B* and falls to the concave grate *G* as indicated by the arrows. The gases pass through the combustion chamber *C* and thence into the flues of the boiler. The brickwork surrounding the combustion chamber *C* is supported by hollow air-cooled brackets. The main combustion zone being over the middle part of the grate, the walls of the combustion chamber become highly heated; consequently, the fuel, which is generally very moist, is well dried in the fuel chamber. The greater part of the radiant heat is therefore utilized in drying and preparing the fuel, which is a distinct advantage in this furnace.

The air supply is obtained through the openings *L* in the brickwork, these leading from the front of the furnace through the hot brickwork to the back and return, opening both above and below the grate. The path of this air is shown plainly in the plan view; and in this way the air is highly heated before reaching the point at which it is needed for combustion. The draft is easily regulated by the circular dampers *D* located at the front of the furnace. For moderate service, these furnish sufficient air for combustion, but where the fire is forced it is advisable to also open the door of the ashpit.

The rate of combustion in this furnace is subject to no sudden variation. The masonry of the combustion chamber serves as a heat reservoir and always affords a constant temperature; the walls being of a refractory material, tend to keep the rate of combustion steady. For this reason, also, the fuel layer may be comparatively thick without the unburned gases escaping to the stack.



Section through Frankel Furnace

*Translated from an article by A. Brüser in "Maschinenbau."

The grate may be cleaned or the clinkers removed by merely opening the door at the front of the furnace.

This furnace is available for any form or size of steam boiler and is especially suitable for burning low-grade fuels such as lignite. However, all sizes of coal may be burned from culm to nut as well as peat, tanbark, sawdust and refuse of all sorts.

The angle of charging should be suited to the fuel used. In cases where there are frequent variations in the size of the coal, the furnace is provided with an arrangement for stopping the fuel supply when necessary. The cast-iron brackets on which the brickwork is supported form a means for regulating the feed since the size of the opening between the grate and these brackets is arranged according to the size of the fuel and the width of the grate. If there should be a change in the size of fuel used, the grate, of course, can be raised or lowered to provide a proper opening.

The fuel is mechanically supplied through the firing door by an elevator, conveyor or other means.

Boiler Bracing

By A. D. Palmer

In a recent issue a subscriber asks the following question: "How many braces 1 sq.in. in cross-sectional area would it take to brace a boiler 60 in. in diameter, the steam pressure being 80 lb. and the top of the top row of tubes 5 in. above the center of the head?" I have seen the same question asked a number of times, and will therefore figure it out according to the method employed by the Massachusetts examiners.

In a 60-in. boiler, that part of the heads comprising a ring 3 in. from the shell is supported by the flange, and requires no bracing. The lower part of the head is supported by the tubes, the support extending 2 in. above them. Hence the area to be supported by the braces is a segment of a circle as indicated by the shaded portion of the accompanying sketch. To find the area of this segment, employ the formula

$$A = \frac{4 \times H^2}{3} \times \sqrt{\frac{2 \times R}{H}} = 0.608$$

where

A = Area in sq.in.;
H = Height of the segment;
R = Radius of boiler less 3 in.

Substituting in the formula

$$A = \frac{4 \times (20 \times 20)}{3} \times \sqrt{\frac{2 \times 27}{20}} - 0.608$$

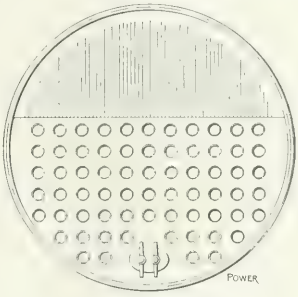
$$= 771 \text{ sq.in.}$$

Multiplying 771 by 80 gives 61,680 lb. as the total pressure upon the segment.

The allowable stress upon a wrought-iron brace of 1 in. diameter is 6000 lb.; hence,

$$61{,}680 \div 6000 = 12 \textit{ braces}$$

are required to brace the head. This number in a 60-in. boiler is too many, as the braces would be in the way when working in the boiler. It is better practice to use larger and fewer braces. For



Shaded Portion Shows Area to be Braced

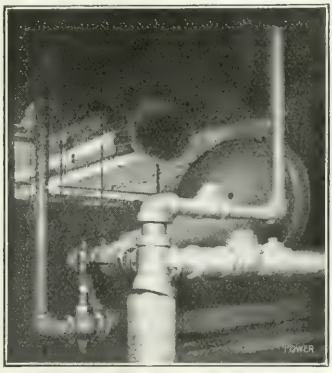
instance, the area of a 1½-in. brace is 1.767 in., and this multiplied by 6000 gives 10,602 lb. as the allowable stress in a 1½-in. brace.

$$61{,}680 \div 10{,}602 = 6 \textit{ braces}$$

which will leave much more working room.

First Bundy Trap

What is said to be the first Bundy steam trap ever installed is illustrated herewith. It was set up in the mill of the Champion Card & Glazed Paper Co., now a part of the Champion International Paper Co., East Pepperell, Mass. Installed in 1890 to take care of the drying coils used in drying paper, it has been in constant use for 22 years and it is probably the first tilting trap ever operated. The trap is 1½ in. in size and



Trap in Use Over 22 Years

up to within a few weeks ago was filling and discharging regularly four times a minute.

This trap has handled during the past 22 years approximately 100,000 tons of water; it is still giving excellent service, and is apparently good for many more years of usefulness. During these years, it is said, the repairs have not exceeded $12.

Razing a Huge Chimney

The chimney shown in the accompanying photograph belonged to the abandoned licorice works in North Third St., Newark, N. J. It was the third largest in that city, being 22 ft. in diameter at the base and 183 ft. high. A 7-ton iron ring was mounted at the top. The chimney was built 20 years ago by the McAndrews-Forbes Co., the owners of the plant.

When the Fire Completed its Work

A contractor purchased it for the brick it contained. In razing the chimney it was necessary to have it fall in a certain direction to avoid damage to adjacent property. In preparing for its fall the brick were removed for about one-half its circumference, timber supports being used as the brick were taken out. When the supports were completed a large quantity of kerosene was poured over them and set on fire.

Aided by a heavy wind, the draft was very strong. It was an anxious 20 minutes before the wooden base gave way and the great chimney rocked to and fro and then fell.

The chimney fell within 100 ft. of its base. The cracks in the illustration clearly show the huge pieces into which the chimney broke. For the information and photograph we are indebted to the *Newark Evening News*.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Practical Points on Knife Switches

By A. G. Campbell

All knife switches made by reputable manufacturers are constructed in accordance with National Electrical Code requirements. This protects the buyer against very serious deficiencies, but it is advisable to inspect every switch carefully before it is installed, in order to avoid small annoyances.

Fig. 1 gives the names of knife-switch parts. The contacts between the break-jaws and the blades should be carefully inspected, as it is at these points that knife switches are most apt to give trouble by overheating.

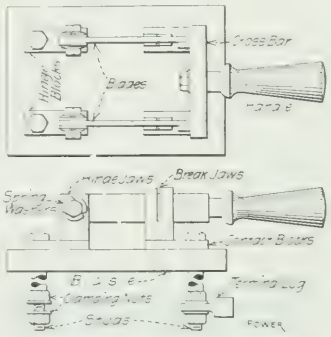
The contact between the hinge-jaw and the blade seldom affects the capacity of a switch, because it is under pressure from the hinge bolt and spring washers. The capacity of a switch is determined by its temperature rise. The code specifies a maximum rise in any part of 50 deg. F. at full load.

Considerable skill is required to effect a good contact or "fit" between break-jaws and blades. After a switch is assembled, the jaws are first bent into correct position either by hand or by driving a block of wood against the distorted portion with a hammer. Then they are "ground in" with vaseline and fine (FF) pumice stone.

Often the fit of a switch is reasonably good at the start, and merely working the blade in and out of the jaws by hand will grind it in. Before the grinding process is started, the portion of the blade that wipes the jaws should be daubed with the vaseline and pumice-stone compound. The abrasive not only grinds the contact to a fit but wears off the lacquer, which, if it remained, might cause bad electrical contact. The surplus compound should be removed with a rag.

A test for good blade contact can be made by trying to insert a "feeler," which is a leaf of very thin steel, mica or paper, between the jaws and blade at the corners and edges. About 0.001 to 0.004 in. is the right thickness for a feeler. An excellent feeler can be made by hammering down to a knife edge the edges of a strip of very thin metal possibly 4 in. long and ¾ in. wide. If the feeler slips in at any point, it is evident that the fit is poor at that point and the contact bad. Proper forming of the jaw will correct the difficulty. There have been cases where switches have been made to carry, without excessive temperature rise, currents 50 per cent. greater than their normal ratings by merely fitting the jaws accurately to their blades.

About 1000 amperes per square inch of copper cross-section and 50 to 75 amperes per square inch of sliding contact surface are usually allowed in designing switches. A switch that will carry 1000 amperes with 20 deg. temperature rise will carry probably 2000 amperes with about a 60-deg. rise. The radiation of heat from the switch increases more rapidly than does the rise in temperature, and as the heat generated varies as the square of the current, it is



A Double Pole Knife Switch

evident that the temperature rise will be somewhat less than proportional to the square of the current.

A switch will break about twice the voltage with alternating current that it will with direct current, the amperage being the same in both cases. The insurance code recognizes this and specifies that "for 100-ampere switches and larger, the spacings for 250 volts with direct current are also approved for 500 volts alternating current."

The voltage drop between the terminal blocks of a good switch should not exceed about 12 millivolts per blade with full-load current.

Quick-break switches have an auxiliary breaking arrangement, actuated by a spring, making it difficult to draw an arc even if the switch is opened slowly. In general, the quick-break attachment is relatively delicate and apt to get out of order. Where feasible, it is always better to use a switch without a quick-break attachment.

Single-throw knife switches should be so mounted that gravity will tend to open rather than to close them. Double-throw switches can be mounted horizontally, but often when so mounted it is inconvenient to make connections to them, and they do not work in well with many switchboard arrangements; hence they are often mounted vertically and an insulating guard, possibly of wood, is arranged so that it may be slipped over the jaws on the lower terminals of the switch to prevent accidental contact.

Usually it is best to connect a switch so that the break-jaws will be "alive" and the blades "dead" when the switch is open. The blades expose more surface and extend further than do the jaws; hence they are more liable to accidental contact and short-circuits than are the jaws.

Inclosed snap switches are usually preferable to knife switches where it is feasible to use them. Snap switches can be obtained for breaking currents as great as 30 amperes at 250 volts. The unskilled person in opening and closing a knife switch is apt to draw an arc between the contacts and in closing the switch to enter the blades only part way in the jaws; both practices will pit the metal and ultimately ruin the switch. This condition cannot occur with a good snap switch. Only indicating switches should be installed.

Power Factor Chart for Three-Phase Circuits

By Charles A. Phillips

The accompanying chart shows the relation between the kilovolt-amperes per phase, the power factor and the total kilowatts in a balanced three-phase circuit. Three pairs of scales are given in order to obtain a wide range without making the chart of unwieldy size. In using it, the two scales of the same letter must be used; for example, if the kilovolt-amperes are located in the horizontal *A* scale, the corresponding kilowatts will be found in the vertical *A* scale.

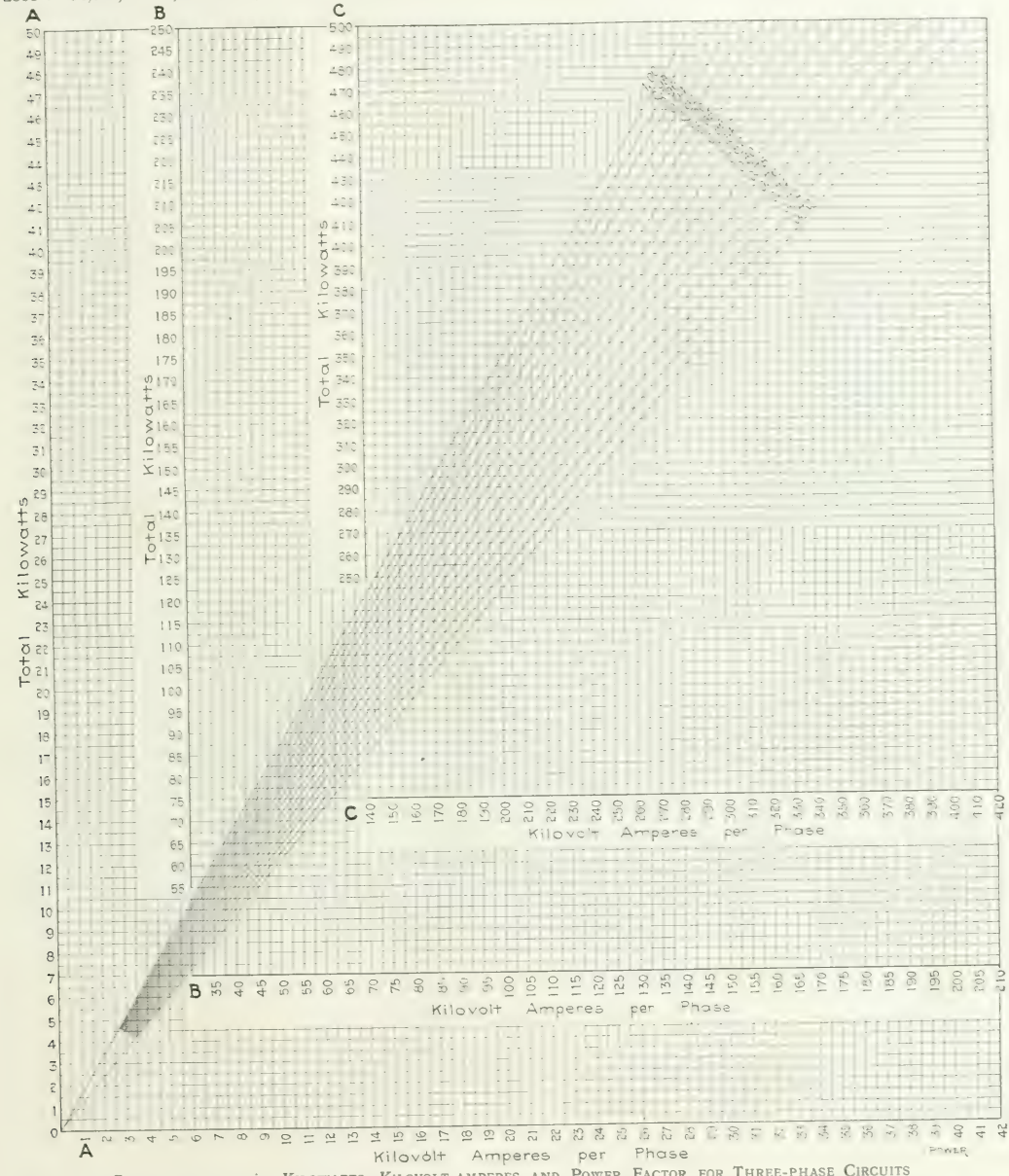
The method of using the chart is almost obvious from inspection of it. If the kilovolt-amperes and the kilowatts are both known, the number on the diagonal line which cuts the intersection

of the kilowatt and kilovolt-ampere lines will be the power factor.

Suppose, for example, that a 2300-volt circuit is carrying 15 amperes per leg; the volt-amperes per phase will be 15 × 2300 = 34,500, which, of course, is 34½ kilovolt-amperes. Also suppose that the kilowattmeter shows 43 kw. Tracing to the right from 43 kw. in the *A* scale and up from 34½ kilovolt-amperes in the corresponding bottom scale, these two lines will meet on the diagonal line marked 0.72; therefore, the power factor of the circuit is 72 per cent.

Again, suppose that a 500-volt motor circuit was taking 250 amperes per leg and the power-factor meter showed 88 per cent.; how many kilowatts would the circuit be taking?

The volt-amperes being 500 × 250 = 125,000, the kilovolt-amperes are 125. This number will be found in scale *B* at the bottom of the chart; tracing up from that point to the 0.88 power-factor line and then straight across to scale *B* at the left, the number 190 will be found there; the power in the circuit, therefore, is 190 kw.



RELATIONS BETWEEN KILOWATTS, KILOVOLT-AMPERES AND POWER FACTOR FOR THREE-PHASE CIRCUITS

If the switchboard be equipped with a voltmeter, ammeters, a wattmeter and a power factor indicator, the chart will be found useful in checking the accuracy of the meters with respect to each other

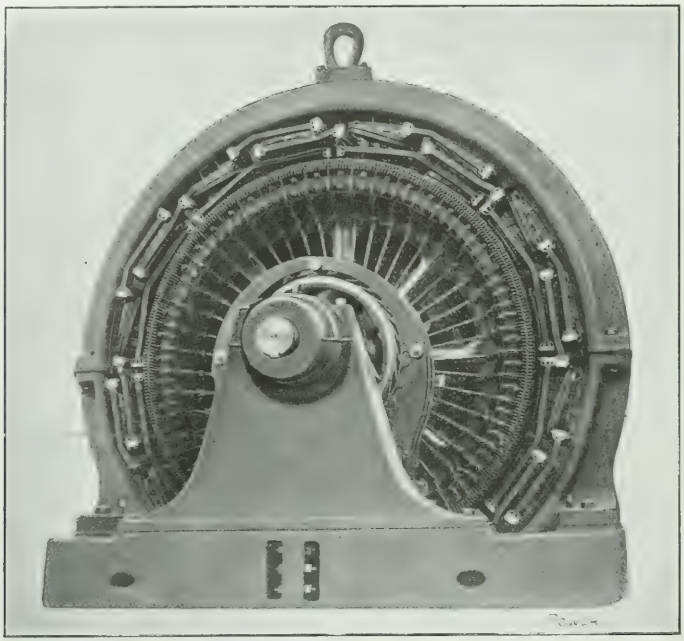
A 7500-Kw. Rotary Converter

Real estate in all large cities is so expensive that it is imperative for public-service companies to use every square foot of substation-floor area most effectively. In rotary-converter substations a very large portion of the requisite floor space is occupied by the converters, and much study has been given by electrical designers to the matter of increasing the converter capacity per square foot of floor space.

When some two years ago two 25-cycle, six-phase, 600-volt, 3000-kw. Westinghouse rotary converters were purchased by the Interborough Rapid Transit Co., New York, and installed in the space formerly occupied by two 1500-kw. converters of similar characteristics, it was believed that just about the maximum point of concentration had been reached. The output of the station in which they were installed was doubled without increasing the floor area. Now comes the announcement that a 7500-kw. Westinghouse interpole rotary converter (600 volts, six phases and 25 cycles) just installed in the Ninety-sixth St. substation of the Interborough company occupies but a trifle more floor space than was occupied by each of the 3000-kw. machines which were previously the standard.

Although guaranteed to take care of load swings, such as are inherent to heavy railway service, up to 7500 kw., the machine is said to have successfully handled swings one-third greater than its rating, or of 10,000 kw.

The accompanying picture gives a view of the converter on the alternating-current side, showing clearly the equalizer connections and the method of connecting the various field-magnet coils.



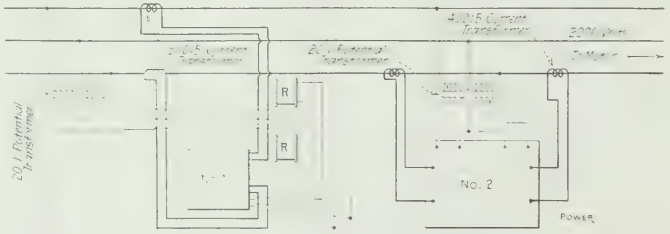
A 7500-KILOWATT ROTARY CONVERTER

LETTERS

Unexpected Wattmeter Readings

I wish to submit to practical readers of POWER the following question in polyphase power measurement:

In measuring the load of a 600-hp. three-phase synchronous motor, supplied with current at 30 cycles and 2200 volts, I had two wattmeters connected as shown by the accompanying diagrams. No. 1 meter is a Westinghouse graphic polyphase wattmeter rated at 5 amperes and 100 volts; No. 2 is a G. E. polyphase portable wattmeter rated at 5 and 10 amperes at 150 volts. Both meters when compared checked very closely.



MR. CROTEAU'S WATTMETER CONNECTIONS

As I was checking the power factor of the motor I told the motor attendant to increase the excitation current of the machine, and as soon as this was done I noticed that meter No. 1 was recording about half load and meter No. 2 full load. Why should this be so?

In the case of a load of exactly 50 per cent. power factor, using two single-phase wattmeters, one meter will register 0 and the other meter will register the total power, the sum of the two readings being the correct power. But when the power factor becomes less than 50 per cent., one meter registers more than the total power and the other registers backward an amount sufficient to make the total indicated power correct.

In my case, as I am using two polyphase wattmeters properly connected, the registration should be correct under all conditions of load.

J. A. CROTEAU.

Thetford Mines, P. Q., Canada.

Arc Lamp Operation

In the section of the Catechism of Electricity which appeared in the issue of Feb. 13, the answer to question No. 1193 states that the upper carbon of an open arc lamp does not actually burn more rapidly than the lower carbon, but wastes away more rapidly because of the transfer of carbon particles from the positive to the negative tip. This reply is partly incorrect; the upper carbon tip actually burns more rapidly than the lower because a greater portion of it is heated to a high temperature and oxidation is therefore more rapid. The carrying of particles from positive to negative is slight.

The answer to question 1198 is somewhat misleading, though correct. The candlepower ratings are never realized in actual illumination; they are merely nominal. The actual mean spherical candlepower is about 400 in an open lamp and 150 to 300 in inclosed arcs, according to the kind of current used and its value; it is less with alternating than with direct current.

Cleveland, Ohio. C. W. HILL.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

The Diesel Engine Ship "Selandia"

The largest oil-power vessel thus far built has just been put through a series of trial runs which are said to have more than vindicated the predictions made for her. This vessel, named the "Selandia," is the first of three that are being built by a Copenhagen firm for service in the Far East; the second of the three, the "Jutlandia," was announced recently. They are twin-screw ships.

The hull is 370 ft. long between perpendiculars and 53 ft. beam, with a depth molded of 30 ft. The ship has been designed to carry a dead-weight cargo of about 7400 tons at a service speed of 12 knots. Extensive accommodation is provided for a large number of passengers in a deckhouse amidships. This passenger accommodation is of a high class, with cabins and bathrooms *en suite*, and the ships will be regarded with special interest, since they are the first oil-driven ships built for regular passenger service.

The Engines

The feature, of course, is the machinery. The engines are designed to work on the four-stroke cycle and each of the two shafts is driven by an eight-cylinder Diesel engine; the diameter of the cylinders is 20⅞ in., and the stroke 28¾ in. The normal speed is 140 r.p.m., at which each engine develops 1250 shaft horsepower. These engines have cross-heads as in ordinary marine steam practice, but the crank pit is completely closed in.

There are also two auxiliary Diesel engines of 200 hp., which drive the lubricating, cooling-water, sanitary and bilge pumps, the refrigerating plant, etc., in addition to a dynamo supplying electricity for lighting, fan driving, winch operating, air compressing, etc. The consumption of oil was measured on the trials and found to be 166 grams, which equals 0.366 lb., per indicated horsepower-hour; this included the oil used by the auxiliary engines, which during the trial were developing about 70 indicated horsepower. The mechanical efficiency was found to be 84.5 per cent.

Each of the engines is divided into two sections of four cylinders each, as indicated in the general view, Fig. 1. The cranks of each four-cylinder group are in pairs 180 deg. apart; each complete group of four cranks is set 90 deg. from the four cranks of the other group. This arrangement gives a diagram of turning moments the maximum of which is about 1.35 times the mean, which indicates that vibration will not trouble the passengers. It may be pointed out that this is a better figure than can be obtained from a four-cylinder two-stroke engine, which is regarded so often as the equivalent of an eight-cylinder four-stroke engine.

The cylinders are mounted on a massive casing and through-bolted to the base. This casing is in four sections and

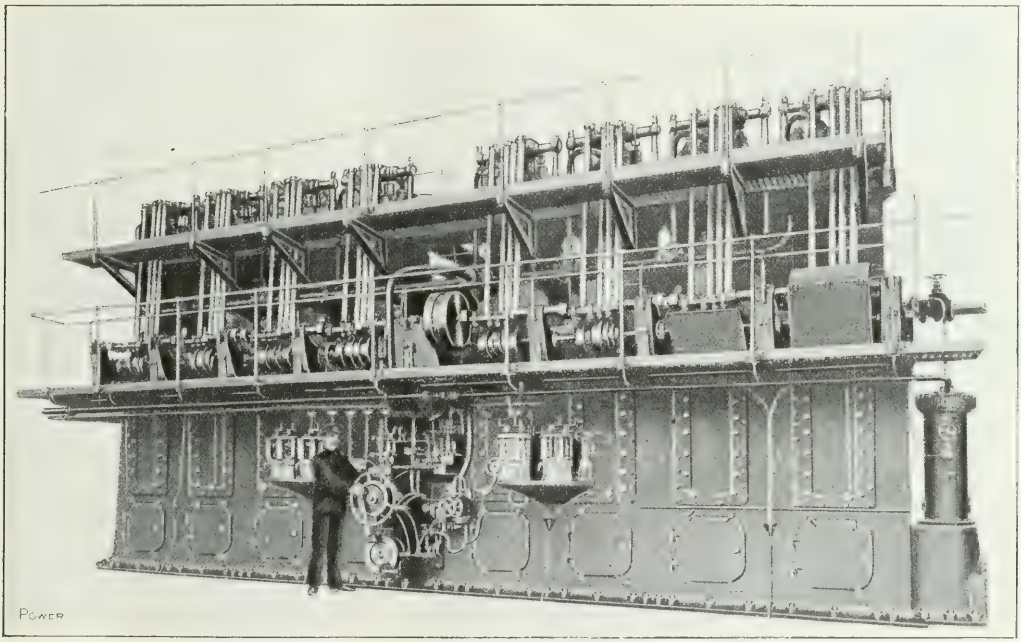


FIG. 1. ONE OF THE ENGINES OF THE SHIP "SELANDIA"

the base is in two. At back and front are doors. At the back the doors are deep and are hinged, the fastenings being dogs held down by flynuts. There is a door opposite each crosshead, besides a middle door giving access to the camshaft gear and rod drive. On the front there is below each cylinder a door fastened by studs. These doors carry the water-cooled crosshead guides. Below each of these doors is a smaller hinged door closed by flynuts.

All the valve-gear is on the front of the engine. The valves are operated by overhead rocking arms supported by separate mandrels, carried in two standards mounted on lugs at the sides of the cylinders. Heavy brackets bolted to the top of the crank casing carry the bearings of the camshaft and also a layshaft. From the camshaft the motion is taken to the overhead rockers by stiff hollow push-rods.

The engines are started, of course, by compressed air; the air pressure is 300 lb. per square inch, and is maintained by a two-stage motor-driven compressor. Air is taken from the 300-lb. tank by another compressor driven from the forward end of the main engine shaft and compressed up to 800 or 900 lb. for use in injecting the oil into the cylinders.

Reverse Gear

Reversing is effected by sliding the camshaft longitudinally so as to bring another set of cams into alignment with the push-rod rollers. The accompanying sketch, Fig. 2, shows the arrangement of the camshaft drive. An intermediate short shaft *A* is geared to the crankshaft in the ratio of 2 to 3 and therefore runs at two-thirds crankshaft speed. Its motion is transmitted to a second short countershaft *B* by means of two connecting-rods coöperating with crankpins 90 deg. apart. The shaft *B* is geared to the camshaft *C* in the ratio of 3 to 4, bringing the speed of the camshaft down to one-half that of the crankshaft, as is the case in all four-stroke engines.

The method of sliding this shaft and disengaging the rollers from the cams to allow it to move is very ingenious, though it introduces a second layshaft along the front of the engine having eight long crankpins upon it. Each crankpin on this secondary or weighshaft *D*, Fig. 2, carries four short links, each attached to a pin on the foot of one of the push-rods, close to the roller, to hold the lower end of the rod in position while suspended from the rocker above. This weighshaft can be rotated through almost a complete revolution by a little compressed-air reversing engine on the starting platform, through a vertical shaft fitted with a worm gear with ball thrusts at each end, the arrangement being exactly like the barring-around gear of a steam engine, except that the weighshaft cannot make a complete revolution. It differs also in that in both ahead and in astern gear the cranks point inward toward the cylinders, the valve rods being thus held by the little links over the center of the camshaft, and so the rollers are in position to be operated by the cams.

The neutral or stop position is obtained by a half revolution of the weighshaft *D*. This makes the crank arms point outward from the cylinders, and the valve rods are therefore swung out clear of the cams and receive no motion from them. The sliding of the camshaft is then effected by the continued rotation of the weighshaft. A roller carried on a pin fixed in a sleeve fitted between two collars on the camshaft travels in a single incline cam path cut in the periphery of a cast-iron drum mounted on the weighshaft, shown in Fig. 2, and which can also be seen in the center of the weighshaft in the general view, Fig. 1,

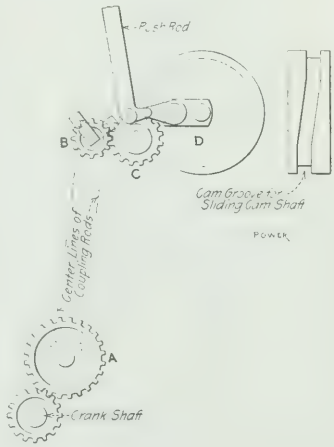


Fig. 2. Part of Valve Gear

the incline meeting the roller when the cranks near their outer position—that is, when the rollers are off the cams. Thus, as the weighshaft continues to revolve, the incline travels around and moves the pin and the camshaft longitudinally just far enough to shift one set of cams out of the line of the valve rods and put the other set in line. Continued rotation of the weighshaft swings the ends of the push rods back into alignment with the cams, this time, however, the reverse-motion cams. During the recent trial runs the change over from full speed ahead to full speed astern was effected in 10 sec.

General Control

There is one main starting lever, which has to be drawn to one extremity of its motion, called the neutral position, before the reversing engine can be started. In this position both the compressed air and the fuel are shut off from the main engines, and to this extent the arrangement is "fool-proof." The small reversing engine (reciprocating type), driven by 300 lb. compressed air, is then started, and rotates the weighshaft *D* to shift the camshaft into the required position, ahead or astern, as the case may be, and restore the push rods to the working positions, as just described. The details of the mechanism are such that the main lever cannot be shifted from the neutral position until the push rods have been replaced in alignment with the cams. Only when this has been done can the main lever be put into a central position, in which it enables the 300 lb. air supply to pass into the cylinder; this supply, being carried six-tenths of the stroke, gives facility for starting the engine irrespective of the position of the cranks.

When the engine has got under way with compressed air, the main lever is pushed still further over into the oil-supply position. The lever "gate" is provided with a notch at the front for the neutral position, another a third of the way along, for the compressed air for starting and reversing, while on the last third of the "gate" length there are numerous evenly divided notches for varying the volume of oil fuel supplied to the engine so as to vary the power developed. The operating lever is centrally mounted on the front of each engine, conforming closely to the handling appliance of the ordinary steam engine.

A small Aspinall governor is provided to cut off the fuel supply when the speed exceeds the normal, and thereby prevent racing if the propeller should lift out of water, as it easily may in rough weather. The governor has no control over the speed below this maximum point.

For the delivery of fuel to the injection valves there are two pumps on each main engine, each pump supplying four of the cylinders. From the pump the fuel is fed to a small box on the back of each cylinder, and in these boxes the pressures equalize themselves, so that all cylinders receive equal quantities. It would seem that a balance is made between the pressure behind the fuel and the air pressure in front of it to determine the quantity admitted for injection, according to engine speed. The regulating handle lifts the suction valves of the fuel pumps in similar style to that adopted on many types of Diesel engines, and thus varies the pump charge. This appears to reduce the quantity of fuel that will force itself against the air pressure into the injection-valve chamber. Each fuel box has a regulating valve for adjustment. To prime the fuel pipes there is a hand pump for each group of four cylinders. A bypass can be opened on each injection valve to release the air from the fuel pipes, which, after filling, overflow into drains which extend down the back of the engine.

A special feature of the injection valves is their inward travel. Instead of using the familiar needle valves, opened outward to permit the charge of fuel to be atomized into the cylinder, the builders have adopted a mushroom-head valve, which opens downward into the cylinder. The usual atomizing disks are retained, so that the fuel enters the combustion chamber in the same state as if it were passing a needle valve. The mushroom head, however, spreads the fuel around the combustion space.

Automatic Devices

In order to prevent dangerous pressures arising inadvertently in the cylinders there are relief valves to each combustion chamber, these being fitted into the sides of the cylinder heads. Furthermore, in order to prevent back pressure in the cylinders when reversing, a device is employed on all cylinders to relieve the pressures when the engine is stopped. This is effected by a trip-gear device on each exhaust-valve motion. Under the rocker of the valve is an upright bar pinned upon the cylinder cover, and through a slot in this bar passes a rod attached to the front end to the exhaust-valve push rod and loaded at the back end with a spring, which keeps the upright bar against a collar on the rod.

When the engine is stopped and the weighshaft moved over to carry the push rods clear of the cams, the exhaust-valve push rods exert an outward pull upon the trip-gear springs, causing the upright bars to move toward the front of the engine. This movement draws each bar under a roller pivoted on the flank of each exhaust-valve rocker, forcing the latter to open the exhaust valve to the extent of 2 mm., thereby relieving the compression for starting.

An ingenious automatic starting valve is employed. An airpot is fitted between each starting-valve stem and the overhead rocker which operates it. Normally, a spring in the airpot pulls the overhead rocker downward at the back end, so that the front end lifts the push rod and roller clear of the camshaft. During the running of the engine the starting-valve links are, therefore, motionless. So soon as the regulator handle opens up the air supply for starting, this air pressure acts upon the piston in the airpot, knocks up the overhead rocker, and brings the roller end of the push rod down upon the camshaft. With 300 lb. in the airpot, a rigid engagement between valve and rocker is maintained, and the starting air valves operate then in the ordinary manner. The air travels along a hollow spindle in the pot, and, therefore, directly the regulator handle is moved over to the fuel supply and cuts off the air, the starting valves are automatically relieved of pressure.

The engines for the "Selandia" were built by Burmeister & Wain, of Copenhagen.

CORRESPONDENCE

More Trouble Running at Full Compression

In a recent number of POWER, I noticed a letter in answer to an inquiry as to why a gas engine would not run at full compression. I thought it might be interesting to the inquirer if I stated a case from my own experience. I was called to a gas engine in London one day because it was behaving in a similar manner to that described in POWER. It would start up well and run at a moderate speed until full compression was put on; then it would suddenly miss fire for several cycles, pull up again, miss fire and gradually stop altogether. This puzzled me greatly for some time; I went over all the probable causes, valves, heat of tube (it was tube ignition), etc., and at last it occurred to me to start up again and investigate the suction at the gas bag. I immediately discovered the cause of the trouble.

FIG. 1. LIGHT-SUCTION CONDITION

FIG. 2. HEAVY-SUCTION CONDITION

I found that a good healthy suction took place while running light, but as soon as the piston speed became at all rapid, a choking action occurred at the gas bag. Closer investigation showed that the gas valve had been leaky and too much lubricating oil had been used on the piston. In consequence, oil had got down the pipe between the gas valve and the bag. This pipe was in the form of a wide U so that at moderate suction the oil remained at the bottom of the pipe, as indicated in Fig. 1, but as the speed of the gas increased it pulled the oil along the pipe to the bend, where it choked the suction of gas (see Fig. 2) and the engine slowed down until the oil resumed its normal position again, when the engine picked up speed again only to slow down again and eventually stop.

When the pipe was cleared of oil the engine ran beautifully. Of course, the compression had nothing to do with the trouble, but the engine behaved as though it had.

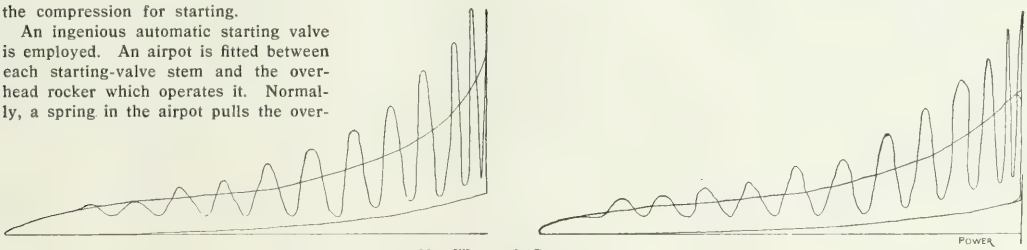
G. H. HUMM.

Loughboro, England.

Freak Indicator Diagrams

Perhaps nothing is more interesting to the studious engineer than the consideration of freak indicator diagrams. Two such are reproduced herewith. The engine has a single cylinder 6¾ in. bore by 15 7/16 in. stroke and works on the usual four-stroke cycle. It is controlled by a hit-and-miss governor, scavenging on the idle strokes; the ignition is electrical, with make-and-break igniter; the spark was well advanced when the diagrams were taken, and a Crosby gas-engine indicator was used, equipped with a 280-scale spring. [The diagrams are reproduced here full size.—ED.] Metallic surfaced cards were used, together with brass points, the pencil being held on during three complete cycles.

In each case two cycles were perfectly normal and were so nearly alike that the lines can be distinguished only by close inspection, though the tracing points were sharp and the diagrams distinct. Superimposed on each expansion line was the violently wavy line shown. This has been traced as a full line, but on the original card the tracing point failed to stay on the paper continuously, making a dotted line record. The engine was being tested under nearly full-load conditions at 260 r.p.m. with a prony brake and gave no evidence of undue stress. Can any of my fellow readers explain the oscillations of the pencil?



MR. WESLEY'S DIAGRAMS

G. M. WESLEY.

LaFayette, Ind.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Ammonia Absorption Refrigerating System

By Fred Ophuls

In the Aug. 23 issue of Power a short article appeared explaining the operation of a refrigerating system in general and of the ammonia absorption refrigerating system in particular. A more elaborate description of the latter system, showing the function of each apparatus, is given later. To assist in this work and show the relative positions of the apparatus the outline sketch is presented, together with tabulations to demonstrate the effect that different conditions of operation have upon its economy.

When designing and installing a refrigerating system to perform a given duty the conditions under which the plant will have to operate must be most carefully considered, particularly the temperature and the quantity of the condensing and cooling water available and the temperature at which the refrigerating duty must be performed.

The plant under consideration was used to cool calcium-chloride brine and in Table 1 are given the fundamental quantities upon which the various calculations made are based. Four different sets of operating conditions were assumed, the first two with 8 gal. of 72-deg. water and the last two with 4 and 3 gal., respectively, of 54-deg. water, per minute per ton of ice-melting capacity used for cooling and condensing.

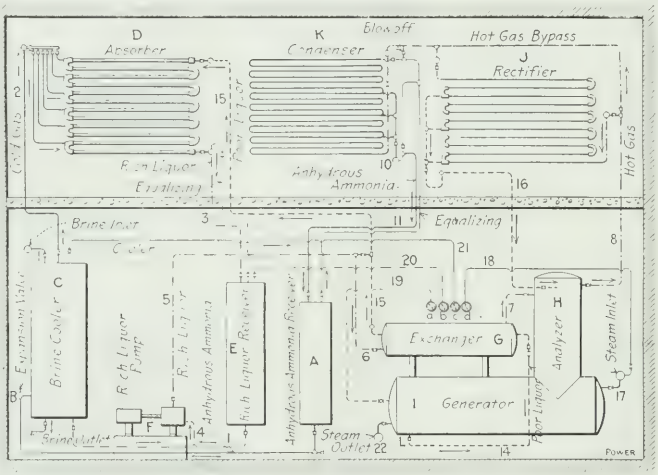
While the refrigerating duty is the same in each case, the temperature to be obtained in the refrigerator, that is, the average temperature of the brine, is assumed as — 12 deg. F. for the first three and + 8 deg. F. for the last set of figures. This change in the brine temperature is made to demonstrate its effect upon the economy of the system, the other conditions being nearly the same.

Ammonia, as the refrigerating agent, is used in the liquid anhydrous state in the refrigerator, where, by its evaporation at a low temperature while being maintained under a moderate pressure, it produces cold. The intensity of the cold produced depends upon the pressure under which the ammonia boils and the amount of cold upon the quantity of the liquid fed into and evaporated in the cooler.

Liquid ammonia can be purchased in the open market and the simplest refrigerating system would consist of a set of cooling coils, a brine cooler or other type of refrigerator to which the drum containing the ammonia would be connected and the liquid ammonia fed as required through a pressure-reducing or expansion valve, the other end of the refrigerator being open to the outer air or submerged in running water to allow the ammonia vapor to escape. Such a system would be dangerous, because ammonia fumes inhaled in large quantity are fatal, and it would be expensive as the liquid costs from 20 to 25c. per pound. Each pound can in evaporating absorb only about 450 B.t.u., or its cooling effect is equivalent to the melting of a little over 3 lb. of ice, the latter costing in large quantities about 0.15c. per pound or, for 3 lb., not quite one-half cent. Using the ammonia in this simple way would therefore cost from 40 to 50 times as much as ice.

As ice cannot be used for producing temperatures much lower than 40 deg. F., and for other good reasons, means have been devised to use ammonia for this purpose and, to avoid unnecessary expense and accidents, save the vapors formed and bring them continually back into the liquid form to be used over and over again. The only additional ammonia that must be supplied to a refrigerating system of this kind after it has once been completely charged is that which is lost through leaks and from other causes beyond the control of the operator. The ammonia is alternately in the liquid and the gaseous state and passes in a closed cycle through the various vessels of the system in the following rotation while the plant is in operation (see accompanying illustration):

A. Liquid ammonia receiver or storage tank.



Outline Sketch of Absorption Syetem

TABLE 1. FUNDAMENTAL QUANTITIES

	Number of calculation	1	2	3	4
	Cooling and condensing water: Initial temperature	72	72	54	54
1.	Cooling and condensing water: Quantity over condenser	4	4	4	3
	Cooling and condensing water: Quantity over absorber	4	4	4	
2.	Refrigerating duty in tons of ice-melting capacity per 24 hr.	125	125	125	125
3.	Temperature of brine: Initial	—8	—8	—8	+12
	Temperature of brine: Final	—16	—16	—16	+4

All temperatures are expressed in Fahrenheit degrees; weights in pounds; water quantities in gallons per minute per ton of ice-melting capacity per 24 hours.

A ton of ice-melting capacity or ton of refrigeration is equivalent to the absorption from the refrigerator of 200 B.t.u. per minute, 12,000 B.t.u. per hour or 288,000 B.t.u. per 24 hours.

Pressures are expressed in pounds per square inch gage.

Amounts of heat absorbed or rejected are specified in B.t.u. per minute unless otherwise specified.

B. Expansion or pressure-reducing valve.
C. Brine cooler or refrigerator.
D. Absorber.
E. Rich-liquor storage tank.
F. Rich-liquor pump.
G. Exchanger
H. Analyzer.
I. Generator.

TABLE 2. DERIVED QUANTITIES
Brine Cooler

	Number of calculation	1	2	3	4
4.	Pounds of liquid ammonia fed into cooler per min.	54.4	54.4	52.2	51.3
5.	Pressure in cooler	3.4	3.4	3.4	15.8
6.	Corresponding boiling point of anhydrous ammonia	—19	—19	—19	1

J. Rectifier.
K. Ammonia condenser, finally returning to
A. Liquid ammonia receiver or storage tank.

The pipe line 1 connects the ammonia liquid receiver with the expansion or pressure-reducing valve *B* and the brine cooler *C*. Through this pipe the liquid flows, as regulated by the valve *B*, from the receiver *A*, where it is stored, to the brine cooler or refrigerator *C* and enters the latter under a pressure suitable for the temperature required in it. The weight of ammonia fed into the cooler is determined by its temperature just before it reaches the valve *B*, its latent heat at the cooler pressure and the quality and temperature of the vapor leaving it.

On this basis, the weight of liquid, in pounds per minute, circulated through the system for each of the four sets of calculations given in line 4 of Table 2 are figured. The refrigerator *C* may be of any construction suitable for the work to be performed.

The ammonia vapor, produced by the evaporation of the liquid in the cooler, is drawn away through the pipe 2 into the absorber *D*, where it is absorbed in a comparatively weak solution of ammonia in water, called weak or poor liquor, producing a rich liquor; that is, water practically saturated with ammonia at the pressure in and the temperature at which it leaves the absorber. The function of the absorber is to draw the ammonia vapor from the refrigerator and prepare it for the second stage of the process, which is to compress the vapor preparatory to reliquefying it.

In the compression system of refrigeration the ammonia vapor is drawn into the compressor and compressed by mechanical means to the desired pressure, while in the absorption system the affinity that water has for anhydrous ammonia is made use of for this purpose. Water in absorbing ammonia does not increase in volume materially, although it absorbs from 500 to 1000 times its volume of the vapor. The strong liquor retains the ammonia in a greatly compressed form.

In Table 3 the quantities pertaining to the operation of the absorber are given. Attention is called to the effect of the temperature of the poor liquor entering on the total heat rejected from the absorber. In the second set of figures the temperature of the poor liquor is nearly 80 deg. F. higher than in the other cases and this comparatively small increase has caused the amount of heat to be removed in the former case to be almost doubled.

To obtain the best results from an absorber, it should be constructed so that, with the temperature and quantity of cooling water available for this apparatus, the final temperature of the liquid leaving it is as low as can be reasonably expected when allowing a proper construction expense for the apparatus.

The weight of ammonia that can be absorbed in water increases as the temperature of the water decreases; that is, the colder the water the more ammonia it will absorb, and increases also as the pressure at which the absorption takes place increases. It follows that the pressure in the absorber should not be maintained at a lower point than is absolutely necessary to obtain the desired temperature in the refrigerator. This fact is very often overlooked in the installation of this system, for it is claimed that the efficiency of the absorption machine is not materially affected by the absorber pressure. This statement is not in accordance with the actual facts, as will appear later.

It is also economy to keep the amount of liquor handled by the liquor pump as low as possible, not because the pump requires a great deal of steam for its operation, but because the heat lost in incomplete heat interchanges from the poor to the rich liquor is nearly in proportion to the weight of the liquor handled. A small quantity of liquor circulated per unit of work done requires a large difference in the strengths of the rich and the poor liquors. The strength of the rich liquor obtainable in any given size, type and construction of apparatus depends upon its final temperature when leaving the absorber and on the pressure; while the strength of the poor liquor is governed by the temperature of the steam in the generator coils and by the pressure existing in the ammonia part of the generator. The difference in the strengths of the liquors for modern plants ranges from 5 to 10 per cent. by weight. In these calculations 8 per cent. is the difference assumed except in the third case where, to keep the temperature in the generator coils as low as possible, the difference is only 6 per cent.

Knowing the strengths of the liquors and the weight of ammonia to be circulated per minute, the weights of the rich and the poor liquors can be computed and with these the total heat rejected from the absorber; these figures are given in line 18 of Table 3.

The rich liquor leaving the absorber flows by gravity through pipe 3 into the rich-liquor storage tank, where it is stored ready for use. The bottom of this tank is connected with the rich-liquor pump *F* by the pipe line 4. This pump takes the rich liquor and forces it through the pipe line 5 into the exchanger *G*, where it takes up heat on its way to the generator from the hot poor liquor flowing through the exchanger on its way from the generator to the absorber.

TABLE 3
Absorber

7	Pressure in absorber	1.9	1.9	1.9	14.3
8.	Temp. of poor liquor entering	107	181	99	105
9	Ammonia vapor entering	0	0	0	12
10.	Temp. of rich liquor leaving	101	101	90	100
11.	Percentage by weight of ammonia in Poor liquor	18	18	22	27
12.	Percentage by weight of ammonia in Rich liquor	26	26	28	35
13.	Weight of rich liquor circulated per min.	558	558	678	468
14.	Weight of poor liquor per minute	503.6	503.6	625.8	416.7
15.	Heat of absorption of ammonia in poor liquor	47,328	47,328	44,631	42,579
16.	Negative heat of vapor entering	2,747	2,747	2,349	2,257
17.	Heat removed from poor liquor	3,022	40,288	5,632	2,084
18.	Total heat rejected from absorber	47,603	84,869	47,914	42,406

TABLE 4
Exchanger

19	Temp. of poor liquor entering	265	265	224	207
20	Temp. of poor liquor leaving	109	185	100	107
21.	Temp. of rich liquor entering	99	99	90	99
22	Temp. of rich liquor leaving	237	175	205	180
23.	Heat removed from poor liquor	78,560	40,288	77,600	41,670
24.	Heat absorbed by rich liquor	74,600	38,000	73,800	39,600

The economy in steam consumption of any system using steam demands that where possible heat interchanges should be effected; that is, where any fluid must be heated and another cooled it is desirable to heat the fluid to be heated with the fluid to be cooled and *vice versa* and this heat interchange should be as complete as possible. In Table 4 the temperature and heat interchanges for the four problems are given. The only difference in the conditions of operation of cases 1 and 2 is the incomplete interchange of heat in the exchanger in the latter case, and this difference is assumed to show the importance of the foregoing statement. The effect of this fault in construction or operation will appear in the final results of the calculations.

To liberate the ammonia from the rich liquor it must be heated and to obtain the ammonia vapor at the proper pressure that will permit of liquefaction with the cooling water available, it must be heated when under that pressure. The liquor pump serves to discharge the liquor into the still or generator against the liquefying pressure.

Before following the course of the liquor from the exchanger into the generator it is well to consider what occurs when a rich ammonia liquor is heated. Taking, for instance, the figures pertaining to this part of the process for the first case, the rich liquor leaves the absorber at a temperature of 101 deg. F. and contains 26 per cent. by weight of anhydrous ammonia in solution. The liquor pump forces this liquor against a pressure of 138.3 lb. per square inch gage into the generator. On its way to the generator the liquor is heated in the exchanger and as soon as the saturation temperature at the pressure in the generator is reached, liberation of ammonia vapor from the solution will begin and end then only when the liquor has reached its final temperature in the generator. The latter temperature is dependent upon the strength to which it is desired to reduce the liquor.

In the first case, the poor liquor is assumed to contain 18 per cent. of ammonia, the ammonia condenser pressure is found to be 138.3 lb. per square inch gage and the final temperature of the poor liquor 270 deg. F. For these conditions the steam in the generator coils of a properly proportioned apparatus will not exceed 275 deg. F., which corresponds to a steam pressure of 30.8 lb. per square inch gage.

When ammonia is liberated from an ammonia liquor, or aqua ammonia, by the application of heat, a certain amount of water vapor is found in the vapor formed. On condensing this vapor a very rich ammonia liquor would be the result; that is, a liquor containing nearly 100 per cent. of ammonia. The disadvantages of using this liquor for refrigerating purposes are that its boiling point is not as low as that of anhydrous ammonia at the same pressure; further, that at the low pressure and temperature of the refrigerator the water in the liquor does not evaporate as freely as the ammonia, so that the final vapor does not contain the same percentage of water that the liquor did from which it is formed. The natural consequence of this condition is that the percentage of water in the liquor contained in the refrigerator constantly increases and the pressure in the latter must be reduced accordingly to maintain the proper temperature.

The efficiency of the system decreases as the percentage of water in the ammonia contained in the refrigerator increases, and it must be purged at frequent intervals. To minimize the effect of this condition, as much of the water vapor as possible must be removed from the vapor mixture before it is condensed and as the amount of water vapor contained in it will decrease as its temperature is decreased, it follows that to attain this end the mixture should be cooled to within a few degrees of the temperature of liquefaction before it reaches the condenser.

Here is another opportunity for taking advantage of heat interchange. The rich liquor leaving the exchanger is not as hot as the vapors rising from the liquor in the generator and an apparatus, the analyzer, is used in which the hot vapor mixture is brought into intimate contact with the rich liquor before the latter enters the generator. The mixture is thereby cooled, and some of the water it contains removed. Table 5 gives the temperature changes occurring in the analyzer, and in Table 6 are data pertaining to the operation of the generator.

The beneficial effect of cold cooling and condensing water and a high temperature in the refrigerator on the steam pressure required in the generator is clearly demonstrated by these figures. In the first and second sets of figures, the amount and temperatures of the cooling and condensing water and the refrigerator temperature respectively are the same; consequently the steam pressure is the same for equal capacity. In the third case, the temperature of the cooling and condensing water is lower and the quantity half of that used in the two previous cases, while the refrigerator temperature is the same and yet the steam pressure is only 7.3 lb. per square inch gage. In the fourth case, the water temperature is the same as in the third case, while the quantity is only three-quarters that used in the former case with a further decrease in the steam pressure to 1 lb. per square inch gage, because the temperature in the refrigerator is 20 deg. higher than for the other problems. These figures show conclusively that even in the absorption system the temperature in the refrigerator plays just as important a part in the economy of the system as in the compression type.

Referring to the illustration again, it will be understood from the foregoing why the rich liquor from the exchanger first enters the analyzer before it flows into the generator. The poor liquor leaves the generator at or near its bottom and flows through pipe 14 into the exchanger and from here as required through pipe 15 into the absorber. In pipe 14 a throttle valve is placed to maintain the required difference of pressure between the generator and the absorber.

This valve is so regulated that the liquid level in the generator is maintained at a predetermined height indicated in the liquid gage-glass provided for this purpose. This is necessary to keep the steam coils always submerged or to prevent the apparatus from becoming flooded with liquor. The steam coils are equipped with a steam trap at their outlet end that all the water of condensation may be drained off as soon as formed and not reduce the effective heating surface of the coils.

The vapor rising from the analyzer still contains considerable moisture and for the foregoing reasons it is further cooled in the rectifier before it is allowed to flow into the condenser.

In Table 7 data pertaining to the rectifier are given. There is a large amount of heat removed in this apparatus and considerable water vapor and ammonia are condensed and reabsorbed in it, especially for the first, third and fourth

TABLE 5
Analyzer

25.	Temperature of vapor rising from generator	270	270	228	210
26.	Temperature of vapor leaving analyzer	242	180	210	185
27.	Temperature of rich liquor entering analyzer	237	175	205	180

TABLE 6
Generator

28	Temperature of poor liquor leaving	270	270	228	210
29	Temperature of steam in heating coils	275	275	233	215
30	Pressure of steam in coils	30.8	30.8	7.3	1
31	Pressure of vapor in generator	138.3	138.3	96.3	99.3

cases, on account of the high temperature of the vapor leaving the analyzer. In the second case, the liquor enters the analyzer at a comparatively low temperature and for this reason the temperature of the vapor leaving it, and consequently its moisture contents, is low.

It is necessary to point out here that the proportion of water to ammonia calculated to be in the vapor liberated in the generator is probably somewhat larger than actually exists in a plant operated under the conditions assumed, but the information obtainable for the temperatures and pressures under consideration is so limited that it was necessary, to complete the calculations and description, to assume that the tension of the water vapor in the mixture is equal to the pressure of water—boiling at the temperature of the vapor mixture. This assumption probably leads to the finding of somewhat larger quantities of water vapor in the mixture than actually exist, but the difference between the assumed and actual amounts cannot be large and the discrepancy in the figures not serious, the more so as it is only desired to show plainly by their aid the functions performed by each of the apparatus of the system separately and also as a part of the whole system.

The function of the ammonia condensers and its effect upon the plant operation will now be considered; the results for the cases at hand are laid down in Table 8. The pressure in a condenser of a certain size and construction depends upon the temperature and the quantity of the cooling and condensing water showered over or circulated through it, modified to some extent by the presence of water vapor and of noncondensible gases in the system. The steam pressure in the generator and other important conditions are subject to the efficiency of this part of the plant.

The heat rejected from the ammonia condenser is determined by the weight of ammonia circulated, the temperature of the vapor entering and of the liquid leaving the condenser and in line 43 of Table 8 the total heat rejected in each case is given.

In the other tables the heat absorbed and rejected in the various vessels has been given with the exception of that absorbed in the generator. The heat interchanges in the analyzer are so complicated, and the heat furnished to the generator so much dependent upon the operation of this apparatus, that the only accurate way of finding the latter is by deduction from the thermal changes of the other apparatus.

The law of the conservation of energy states that energy can neither be created nor destroyed, and from this law it follows that, when any substance is made to do work in a closed cycle, like, for instance, that of a refrigerating system, in which the substance always returns again and again to the same state in the same part of the cycle, the total heat absorbed and the total heat rejected are equal.

In Table 9 the heat balance of the system is shown. The figures for the heat absorbed in the generator, in line 46, were obtained by summing up the heat rejected from the ammonia condenser, exchanger, absorber, poor-liquor line, rich-liquor line and rectifier and deducting from this sum the heat absorbed in the brine cooler and suction pipe, the remainder is the heat absorbed in the generator, neglecting the heat equivalent of the work done by the liquid pump, which is too small to be considered in approximate calculation.

Having found the heat that must be imparted to the rich liquor to drive off the ammonia, the weight of steam that must be fed to the steam coils in the generator can be figured. An allowance must be made in this item for the heat lost by radiation from the exposed surfaces of the generator and pipe connections around it. Table 10 shows in successive steps the calculations involved in finding the steam consumption of the machine. The final figures in line 60 tell the story. While they may be somewhat high in amount they are proportionately accurate.

To complete the circuit of the cycle it is found that the mixture of water and ammonia vapor rises from the analyzer and passes through the pipe line 8 into the rectifier *J*, the condensate returning to the analyzer through the pipe line 16 while the cooled and practically anhydrous ammonia vapor flows through pipe line 9 into the ammonia condenser *K*, where liquefaction takes place and the liquid formed returns by gravity to the liquid ammonia receiver *A* through pipe line 11 and is again ready to do refrigerating work, having completed the cycle circuit.

For convenience in operation, a set of four pressure gages is furnished so that the pressure existing in any part of the plant can be seen at a glance. The gage

TABLE 7

Rectifier

32.	Temperature of vapor entering	242	180	210	185
33.	Temperature of vapor leaving	82	82	65	65
34.	Temperature of liquor leaving	122	122	104	104
35.	Percentage of ammonia in liquor leaving	63	63	63	63
36.	Weight of ammonia vapor entering	83	59 4	68 7	59 1
37.	Weight of water vapor entering	16 5	2 9	9 7	4 55
38.	Weight of ammonia reabsorbed	28 6	5 0	16 5	7 8
39.	Total heat removed in rectifier	43,882	12,315	26,595	13,835

TABLE 8

Ammonia Condenser

40.	Condenser pressure	138 3	138 3	96 3	99 3
41	Temperature of liquefaction	79	79	62	63
42	Latent heat of ammonia at condenser pressure	505 3	505 3	516 8	516
43.	Total heat rejected from condenser	27,840	27,840	27,315	26,777

TABLE 9

Heat Balance. 1. *Heat Absorbed*

44.	In brine cooler	25,000	25,000	25,000	25,000
45.	In suction line	517	517	496	564
46	In generator	105,199	109,226	85,969	63,480
47.	Total heat absorbed	130,716	134,743	111,465	89,044

2 *Heat Rejected*

48.	In ammonia condenser	27,840	27,840	27,315	26,777
49.	In exchanger	3,960	2,288	3,800	2,070
50.	In absorber	47,603	84,869	47,914	12,406
51.	In poor-liquor line	3,525	3,525	3,129	2,084
52.	In rich-liquor line	3,906	3,906	2,712	1,872
53.	In rectifier	43,882	12,315	26,595	13,835
54.	Total heat rejected	130,716	134,743	111,465	89,044

TABLE 10

Steam Consumption

55.	Heat absorbed in generator	105,199	109,226	85,969	63,480
56.	Radiation from generator	1,601	1,900	1,000	800
57.	Total heat supplied	106,800	111,126	86,969	64,280
58.	Latent heat of steam in generator coils	920	920	950	963
59.	Pounds of steam required per min.	116	121	91 5	66 7
60	Pounds of steam used in generator coils per hour per ton of actual ice-melting capacity per 24 hours	55 6	58	43	32

marked *a* is connected through pipe 19 with the generator, the gage *b* through pipe 20 with the absorber, gage *c* through line 21 with the brine cooler and gage *d* with the steam coils of the generator. A pipe connection is also made between the rich-liquor pump and the bottom of the brine cooler so that the latter can be purged from time to time of the liquor which has accumulated. The top of the rich-liquor tank is connected with the top of the absorber so that the pressure in these apparatus can be maintained the same at all time to facilitate the flow of the liquor from the absorber into the tank. The top of the liquid ammonia storage tank is connected by a small pipe line with the top of the ammonia condenser for the same purpose.

It only remains to summarize the foregoing discussion and point out the salient facts step by step. The ammonia-liquid receiver or storage tank *A* is a receptacle in which the anhydrous ammonia is stored ready for use in the refrigerator. In a properly equipped plant the total volume of the receiver or receivers is 10 per cent. greater than the volume of the total charge of anhydrous ammonia in the plant.

The pressure-reducing or expansion valve *B* serves to maintain the proper pressure difference between the ammonia in the liquid receiver and that in the brine cooler or refrigerator and to regulate the amount of the liquid entering the latter for the refrigerating duty performed by the plant.

The brine cooler or refrigerator *C* is the vessel, apparatus or space in which the refrigeration takes place, and the construction of this part of the plant varies with the purpose for which the refrigeration is intended, the amount of the refrigeration and taste and skill in the art of the designer.

Economy in this part of the plant demands that the difference between the mean temperatures required in it and that of the evaporating ammonia shall be as small as practicable in view of the best engineering practice.

The absorber *D* performs the principal functions of the compressor in the ammonia-compression system of refrigeration; which are to remove the ammonia vapors from the refrigerator and compress them preparatory to their reliquefaction. The absorber should be so constructed that the liquor surfaces at which absorption takes place are ample for the work to be done and are located in close proximity to the heat-absorbing or cooling surfaces of the apparatus. Large liquor surfaces in the absorber allow of ready absorption of the ammonia vapors and their proximity to the heat-absorbing or cooling surfaces a low temperature of the absorbing surface of the liquor, resulting in a small difference of pressure between refrigerator and absorber and a rich liquor high in percentage of ammonia contents.

The rich-liquor storage tank *E* should be large enough to hold the complete liquor charge in the plant. The rich-liquor pump *F* draws the liquor from the tank *E* and discharges it against the high pressure of the system into the generator. The pumping of rich aqua ammonia is not as simple a matter as pumping a more stable fluid, on account of the formation of vapor in the pump cylinder caused by the reduction of pressure on the liquor entering by the suction action of the pump. Various patents have been taken out for constructions said to overcome this difficulty. The principal points to observe in the construction and installation of such a pump are small clearance, large valves and valve passages, equalizing pipe to the absorber and as much vertical drop as possible between the bottom of the liquor tank and the pump cylinder.

A gas-bound liquor pump causes trouble on account of its decreased volumetric efficiency, racing and hammering, similar to steam hammers in faulty steam-pipe construction.

The exchanger *G* is a very important part of the plant and serves to transmit the heat taken up by the poor liquor in the generator to the rich liquor entering it. In properly constructed apparatus, the temperature of the poor liquor leaving should not be more than 5 deg. higher than the temperature of the rich liquor entering. The proper difference of temperature between the poor liquor entering and the rich liquor leaving cannot be expressed in degrees of heat as the final temperature to which the rich liquor is raised depends on its strength. Under certain conditions of operation liberation of ammonia can take place in the exchanger, and in that case the total heat taken up by the rich liquor cannot be computed from its initial and final temperatures.

The analyzer *H* serves to partially dehydrate the vapor mixture rising from the liquor in the generator. At a casual glance, it would seem that to obtain maximum economy in steam consumption the rich liquor should enter the analyzer at or near the temperature at which it leaves the absorber, its lowest temperature in the cycle. This condition could be brought about by discarding the exchanger or by an incomplete interchange of heat in the exchanger. With cold, rich liquor entering the analyzer, the vapor mixture leaving it would have a comparatively low temperature and therefore contain but little water vapor, reducing the heat rejected in the rectifier.

The most complete heat interchange in the exchanger and consequent high temperature of the rich liquor entering the analyzer are conducive to best economy, as will appear from the final results of calculations Nos. 1 and 2. In the former the heat interchanged in the exchanger was nearly twice that in the latter, for otherwise the same conditions of operation. The liquor entering the analyzer was 237 deg. F. in the former and 175 deg. F. in the latter case, the heat rejected in the rectifier 43,882 and 12,315 B.t.u. per minute respectively, and, notwithstanding these facts, the steam consumption was only 55.6 lb. in the former against 58 lb. per ton of refrigeration in the latter case.

The ordinary analyzer is a vertical cylindrical tank either forming a dome on top of the generator or a separate vessel, in which a set of horizontal perforated trays are placed, one below the other. The liquor enters the top tray and overflows in thin films into the trays below, affording a large surface of contact with the vapor mixture flowing through it. The perforations in the trays are raised on the upper face so that a thin film of liquor coats the inside of the trays.

The generator *I* serves to liberate the ammonia vapor from the rich liquor. Economy in the operation of this apparatus demands that the difference between the temperature of the steam in the heating coils of this vessel and that of the poor liquor leaving it be as small as possible or consistent with the largest heating pipe surface and its best distribution that can be used in the generator. A difference of only 5 deg. F. in these temperatures requires a large heating surface per unit of capacity of the apparatus and an effective distribution of this surface.

In the rectifier *J* the dehydration of the vapor mixture is nearly completed. The proper operation demands a construction that will permit the reduction in temperature of the vapor passing through it to within a few degrees of the liquefying temperature in the ammonia condenser, a small quantity of cooling water and a comparatively high final temperature f the liquor condensed in this apparatus and returned to the analyzer.

The ammonia condenser *K* should be so constructed that with the temperature and quantity of cooling and condensing water available the minimum practicable pressure of liquefaction is obtained. It is an apparatus used in all types of refrigerating systems.

The final conclusions of the quantitative analyses of the absorption system are the following:

That, contrary to generally accepted views, the steam consumption of the absorption refrigerating increases rapidly with a decrease in the temperature of the refrigerating medium in the refrigerator.

That the quantity of cooling water necessary for efficient operation is double that required for a compression system with a single steam engine and the same as that for a compression system with a compound condensing engine.

Issued Weekly by the
Hill Publishing Company
John A. Hill, Pres. and Treas. Robt. McKean, Sec'y.
505 Pearl Street, New York.
1221 South Michigan Boulevard, Chicago.
6 Bouverie Street, London, E. C.
Hastings House, Norfolk Street, Strand, London, W. C.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "Powpub," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

The Value of Dry Steam

There is steam and steam.

Steam may be just plain steam with exactly enough heat in it to keep it as steam under the existing pressure. In this case it is said to be "dry saturated." If it lost any of its heat, a portion of it would condense.

It may be more than dry. It may be heated just as air or any other gas may be to any temperature above that of dry saturation. In this case it is said to be "superheated."

Or it may, and usually does, carry with it a considerable quantity of unevaporated water. In this case it is said to be "wet" or "moist." Of course, the term "steam" is strictly applicable only to the portion which has been evaporated and is still in the vaporous condition, but the whole mass is commonly referred to as "steam" and its quality indicated by the proportion of the whole, by weight, which persists in the form of vapor.

Steam having a quality of ninety-eight per cent. is a mixture of ninety-eight parts by weight of steam and two parts of unevaporated water. All sorts of clumsy terms, such as "mixture," "steam stuff," etc., are used to designate this material. The water in it has been simply raised to the boiling point but not evaporated, and as it takes at one hundred and fifty pounds pressure, considerably over two and a half times as much heat to evaporate the water as it does to raise it to the boiling point, even from thirty-two degrees the wet mixture has much less heat and potency than the dry steam.

But the moisture in the steam is not only a negative quantity, it is a positive detriment. Its presence aggravates the heat interchange between the working medium and the cylinder walls which is the greatest source of loss in the reciprocating engine and militates against the efficiency and longevity of the turbine by dragging upon its swiftly revolving surfaces and eroding the blades upon which it is projected with an enormous velocity. The first few degrees of superheat, the change from somewhat wet to positively dry steam, has an effect upon turbine efficiency out of all proportion to the difference in heat contents or "available" energy.

There is another advantage to dry steam which is not so often discussed; it does not carry over foreign material from the boiler with it as wet steam does. A case of severe cylinder cutting was traced to the boring out of the boiler tubes and the carrying over by the steam of the fine sharp powder which had not been thoroughly cleaned out. When a superheater is used it will soon become scaled up if some five per cent. of the water is evaporated upon its surfaces.

It behooves one, therefore, when buying a boiler or considering boiler and engine performances to take into account the kind of steam in question. A boiler may get rid of twelve pounds of water for each pound of coal burned, but is the "stuff" which it delivers all steam? And it is not enough, for practical considerations, that this evaporation should be reduced to the equivalent evaporation in dry steam, for the boiler which delivers its steam practically dry is a good deal more than five per cent. better for the man who is going to drive an engine with it than a boiler which delivers a mixture of ninety-five per cent. of steam and five per cent. of moisture.

Two Kinds of Avoidable Explosions

If one planned deliberately to get up an explosion, he could hardly do better than to put kerosene into a vessel like a boiler or heater open for cleaning, especially if it were somewhat warm as a boiler or heater is likely to be, and then to stick a torch into the manhole. It would seem as though any man of ordinary commonsense—and much more an engineer—could foresee the consequences of this combination. But accidents from this cause are of frequent occurrence.

We are advised of a recent one in the plant of the Western Fuel Co., in British Columbia, where one of the engineers, after having washed out the boiler, put some coal oil into it and then started to enter it with an open light to examine the feed-pipe outlet. The explosion was violent enough to tear off the sheet-metal siding of the boiler house, and the man was severely burned.

Another class of accident which we are called upon to record less frequently but still occasionally, is the bursting of a piston which is being heated up in a forge fire. The heating of the air which the piston contained would result in a pressure of less than one hundred pounds, but the presence of a little moisture in the interior of the piston would increase this pressure enormously, while if there were any oil present the conditions for an explosion in the compressed and highly heated air of the interior would be ideal when the temperature reached that of ignition.

Compensation of Consulting Engineers

The compensation of the consulting engineer was touched upon by Charles T. Main in a recent address before the Association of Engineering Societies, of which he is president. The remarks coming from a well known member of the profession deserve special attention since they also reflect the opinion of a considerable number in that field.

The principal contention of Mr. Main was that the compensation of a consulting engineer should not be figured on a time basis, but rather upon the importance of the services rendered. If the advice given effects a saving in the cost of production or causes the client to embark upon an enterprise which will net a large profit, then the fees of the engineer should be commensurate. In support of this contention it is pointed out that the advice is often a concentrated form of knowledge which it has taken years of experience to acquire; during which period the practical experience was considered a part of the remuneration.

Of course, Mr. Main makes it plain that this cannot be applied to the regular pursuit of design and construction where a definite fixed sum or percentage must be charged, the aggregate of which cannot be large unless the undertaking is unusually big.

We agree with Mr. Main that the compensation for engineering services should be in accord with the results attained; it is the same line of argument which we have so often expounded, to the effect that if a fireman, by intelligent handling of the fires, saves ten per cent. of the fuel, he is entitled to share in the pecuniary saving. However, there is this difference in the two cases: the engineer's fee would be influenced to a large extent by his reputation and would probably be fixed in advance, whereas the fireman's compensation would be based upon the actual saving effected; that is, after the amount of this saving had been definitely made known.

Mr. Main ascribes the relatively low prevailing rates of compensation to the natural modesty of the consulting engineer which bars a full appreciation of the worth of the professional services rendered. We are inclined to believe it is more of an economic problem than one of modesty. However, with the elevation of the profession and a recognition of its importance, there should come an opportunity for better financial returns, although millionaire engineers will probably remain a scarcity for many years to come.

Using the Firm's Stationery

The fact that the average young urchin usually has a dirty face does not necessarily infer that he belongs to a slovenly kept household, although he may convey that impression; but the begrimed boy's mother oftentimes believes that his condition is a reflection upon her management of the home.

It is true that a man's shortcomings will react against the interests of those with whom he is closely associated, and this axiom has found ample illustration in the discussions that have been published in this journal on using the firm's stationery.

Some engineers who used the firm's stationery when writing to certain manufacturers of power-plant apparatus did not receive a reply. Was it because the appearance of the letter gave the impression that the firm which the engineer represented was insignificant? Perhaps the letter was ungrammatically constructed, or the words misspelled; it may have been smeared with ink-blots and smudged with grease. It is more than likely that such a letter would tend to produce the impression that the concern whose name appeared on the letterhead figured small in the business world, and that its engineer was equally diminutive.

As a comparison, suppose the letter had been neatly typewritten, grammatically expressed and properly spelled; it would then have given the recipient a better impression of the writer and of the firm which he represented.

While most manufacturing concerns may not waste time on a proposition which does not look good, even to the sending of a catalog, it is not always good business practice to acknowledge only perfection letters. Many an engineer with purchasing power neglects to write carefully and is not always able to spell correctly, but he orders the goods; therefore this question should be considered from all sides.

The engineer should strive to make his business letters reflect the standing of the company with which he is identified, and the manufacturer should not take the standpoint that giving attention to a poorly written letter must necessarily mean a loss of time; it may mean a sale and a permanent customer.

An engineer told us the other day that he has just resigned a good position "because the old boilers were unsafe." Here is a man who rose to the occasion and came down with both feet. Perhaps if he had stayed any longer, he would have "risen" all right—in company with the old boilers.

Many people in all walks of life seem to be exceeding fearful that they will miss the psychological moment. The engineer who knows his work will tell you that every operating moment is one of those hard-sounding elements of time; there is no choice between them.

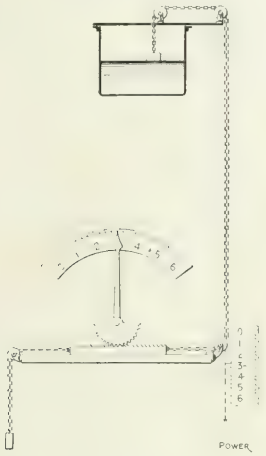
When the plant owner is made to realize that in the black smoke issuing from his stack his money is being wasted in unburned products of combustion, he will not wait for legislation to abate the nuisance.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Water Tank Gage

A tank water gage is made by attaching a gearwheel to the indicator arm, the gearwheel engaging with the rack which slides on the base, as shown. One end of the rack is connected by a chain to the float in the tank; the other is connected to a weight.



TANK GAGE

When the tank is empty, the indicator hand will be at zero. As the tank fills with water the float rises and the weight draws the rack toward the left. This movement rotates the hand over the dial, and indicates the depth of water in the tank.

An indicator can be arranged as shown by the dotted lines with the indicator attached to the float chain.

EDWARD L. JOHNSON.

Brooklyn, N. Y.

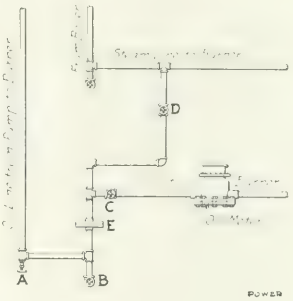
Strainer for Fuel Oil System

The accompanying sketch is of a strainer and water trap on the oil line of my oil-burning system, in which *E* is a flange union one size larger than the pipe. A 24-mesh wire screen is inserted between two pieces of woven asbestos packing.

To clean, close the valves *A* and *C* and open the valves *B* and *D* slowly and blow the sand and grit that accumulate on the under side of the flange coupling out through the valve *B*. Then close the valves *D* and *B* and open valves *A* and *C* and the oil line is clear.

Put a long nipple between the valve *B* and the tee so as to trap the water that comes in with the oil. The valve *D* must be absolutely tight.

I use an over-flow valve on the discharge pipe from the oil pump and leave it partly open and do not have to stop the pump to clean the strainer. I took steam for the oil burner and pump from the top of the boiler dome and tapped the branch pipe to the oil burner from the top of the steam pipe in order to get the dry steam.



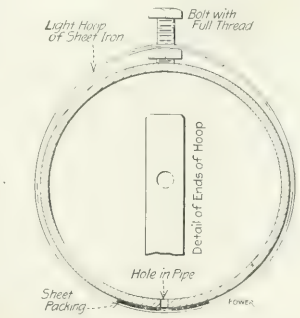
STRAINER FOR FUEL OIL

C. D. COOK.

Turon, Kan.

Temporary Pipe Repair

It frequently happens that a pipe springs a leak and it is impossible to cut it out of service immediately to put in a new section. In such a case the temporary repair kink illustrated herewith may be used to good advantage.



METHOD OF MAKING TEMPORARY REPAIR

Cut a piece of light sheet iron wide enough to cover the leak fully and long enough to fit loosely around the pipe and lap over as shown in the accompanying figure.

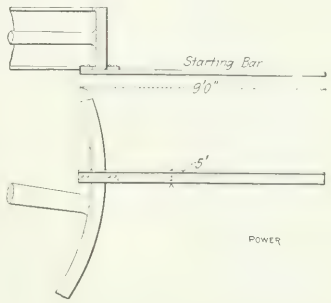
Place a bolt with a full thread against the pipe opposite the leak, as shown, and after slipping a piece of sheet packing under the iron band at the leak, tighten up on the nut. Gently tap the iron band while tightening the nut so as to make it draw up evenly.

LEO C. STAAL.

Pittsburg, Penn.

Channel Iron Starting Bar

The starting bar shown in the illustration saves much time in our engine room. Before its use a 16-ft. belt wheel had to be turned over by means of a tackle; this method was very cumbersome.



CHANNEL-IRON STARTING BAR

The 9-ft. bar is made of 5-in. standard channel iron and weighs about 60 lb. It cost $2.

RULOF KLEIN.

New York City.

Firemen's Bonus System

A bonus system of paying the firemen prevails in a large chemical works, this system being based on these four items: constancy of steam pressure, percentage of coke in ash, stack temperatures and CO_2 in the flue gas.

Records of this information are kept by means of pyrometers, CO_2 recorders, recording gages and by frequent analyses, and at the end of the month the shift making the best showing is paid a bonus which amounts to about $5 per man per month. As there are three eight-hour shifts, this induces a lively competition among the shifts, from which both the men and the company benefit.

As a direct and further result of acquiring this information about their conditions, the company has made a number

of changes in the arrangement of the boiler settings, such as covering the outside of the settings with a course of hollow tile lined with a layer of asbestos, changing the area of the grates, etc., and the showing made by this practice is a saving of about 14 per cent. in the total fuel burned.

M. W. CAMPAU,
Manager Precision Instrument Co.
Detroit, Mich.

Removing Keys

The accompanying sketches show three ways of pulling keys from a Corliss valve stem.

In Fig. 1 is shown a clamp which is made to fit into two grooves chipped in the key. A bolt is passed through the clamp to keep it from spreading. The horizontal top piece is supported by two blocks, and the nut on the vertical bolt is then screwed down and the key is thus pulled upward by the clamp.

In Fig. 2 a hole is drilled in the end of the key and is then tapped for a cap screw. Tightening the cap screw will withdraw the key.

In Fig. 3 is shown a drift made of a piece of ¼-in. octagonal tool steel. A groove must be filed in the key, as shown. A ¼-in. rat-tail file is best for this purpose. If a little kerosene oil is poured around the key, it will find its way down to the binding parts and will sometimes help to loosen the key.

SAMUEL H. FARNSWORTH.
Chicago, Ill.

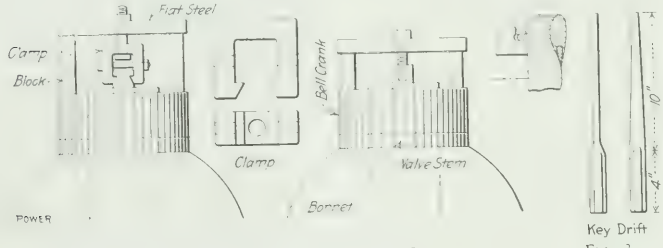


FIG. 1 FIG. 2 FIG. 3

THREE WAYS OF REMOVING KEYS

Canada's License Law

I have followed the discussions on license laws with much interest. Many correspondents seem to think there is graft connected with it in certain states. An assertion of that nature regarding Canada's license law would be laughed at by the engineers themselves. We have the highest standard for stationary steam engineers' licenses on the continent and, furthermore, they are enforced without fear or favor.

Engineers should not overlook the advantages gained by the enforcement of license laws. It compels engineers to learn more of their profession, to start studying and, when started, continue. Many engineers here are receiving higher wages than they were when the law went into effect in 1900, and men now holding low-grade licenses have experienced no reduction in wages over that received before the enactment of the law.

BERT SWANTON.
Vancouver, B. C.

Engine Wreck

Recently the cylinder of a 16x22-in. four-valve engine was completely wrecked, caused by the breaking of the main rod in the outer strap bolt-hole.

This engine at the time of the accident was making 165 r.p.m. with a working pressure of 125 lb. It was loaded to its full capacity, and working perfectly quietly. The rod parted with no warning; the cylinder was broken, the piston split, the piston-rod buckled, and the valves were broken. An examination showed an old fracture, the bright metal of the break being only ⅜ in. thick, and it evidently ran that way for some time. The fracture could not be seen as it was on the back side of the rod and on the dark side of the engine.

The engineer was within 4 ft. of the engine but he could not close the throttle, as it was also on the back side, and the cylinder could not be passed without loss of life. The boiler valves were closed and the water level noted in each boiler. The engineer escaped injury.

BURT M. SEYMOUR.
Delphos, Ohio.

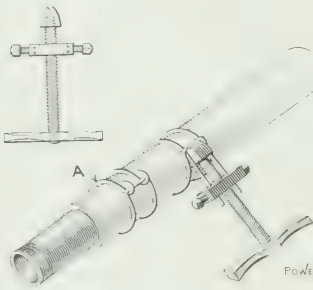
Engineers' Daily Reminder

This idea can be worked out by using a calendar, composed of separate day sheets, and a set of rubber stamps to mark the work to be performed at stated times in the future. Miscellaneous memoranda can be put down under the date it is desired to attend to any particular piece of apparatus. The idea works well, helps make one systematic and can be carried out to any extent.

FRANK MARTIN.
College Point, N. Y.

Home Made Hose Coupler

The hose coupler shown in the accompanying illustration can be easily and cheaply made by most any engineer. It will be found a very useful adjunct to the plant.



HOSE COUPLER

The illustration shows the instrument and its application. The wire clamp is attached to the hose at *A*. No. 8 wire for 1-in. pipe, and No. 6 for 1- to 1½-in. pipe make very suitable clamps.

J. G. KOPPEL.
Montreal, Can.

On to His Job

Good repair men about a steam plant are hard to get and are not appreciated or compensated one-half enough.

Our repair man got an engineer's license and a young man came to take the job. He had a high-school diploma, one from an engineers' correspondence school, and enough recommendations to cover a yard of paper; he also had a set of those perpetual-motion smiles.

The fellows dubbed him professor, and he was well named, for he could talk power house, he knew what he was talking about and work was his middle name.

One night at shutting-down time, when he should have been ready to go home I saw him standing around with a wrench in his hand and asked him what he was going to do. He said he was going to fix the induction-fan engine up a bit as he was tired of hearing it pound. After shutting down I went with him to see what he did. I suspected the pound was in the crosshead. The professor thought so too and took out the wristpin, turned it true and babbitted the boxes. When he started up the pound was still there. Then he leveled the rod and put in a new set of metallic packing; when he started up the pound was gone.

He fooled with the economizer until it raised the feed-water temperature about 15 deg.

One of the generator pits kept filling with oil and had to be bailed out by hand. He made an ejector out of some pipe and connected it to an air line and forced the oil into a barrel.

A motor-drven plunger pump that took care of the drains of the heating system failed; he removed the cap to the suction chamber and put in a new set of suction valves and springs. Then the pump worked worse than before. I thought he was stuck, but he measured the distance from the pump to the receiver, took out the springs, cut off one coil, put them back—and the pump worked all right. He said the trouble was caused by the pump not having a vacuum on account of the hot water and that the head was not great enough to overcome the stiffness of the springs.

He had a third-class license; and why he did not have a first I could not see. He was a shark for knowledge. As soon as POWER came he would grab it and disappear. After he had read it through he would bring it back and talk about the different articles to the profit of all.

A. W. GRISWOLD.

Adams, Mass.

Pump Would Not Force Water

The accompanying sketch shows how a centrifugal pump was recently installed. The pump and motor are located on the river bank, 1800 ft. from the mill.

The electrical energy is supplied by the mill generator and is transmitted to the motor through a No. 000 copper wire on the positive side; the discharge pipe from the pump is used as the negative line, proper connections being made at the motor and the switchboard.

The pump is set 25 ft. below the earth surface in a boxed well and is driven by a 10-kw. motor by means of a vertical shaft turning 1500 r.p.m. The suction pipe is 3 in. in diameter, and the discharge pipe is 2 in. The maximum lift is 8 ft. and the pump discharges against a 65-ft. head.

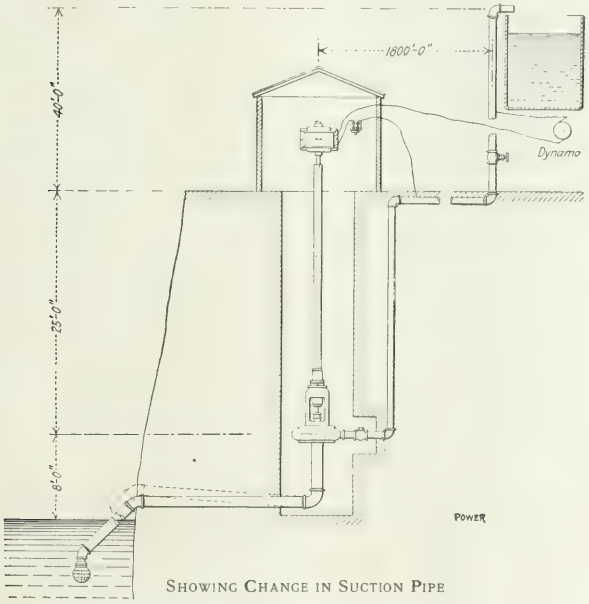
The pump in question will not lift water when the suction pipe is in a horizontal position, although $100 was expended for labor in 10 days in trying to make it do so by priming, etc.

At last the engineer suggested raising the suction pipe about 4 in., as shown by the dotted lines. This was done and the pump has been putting water in the tank at the rate of 6000 gal. per hour ever since.

Why did raising the suction pipe remedy the trouble? I would like to hear from some of the readers of POWER who have had practical experience with centrifugal pumps regarding this case.

J. W. DICKSON.

Memphis, Tenn.



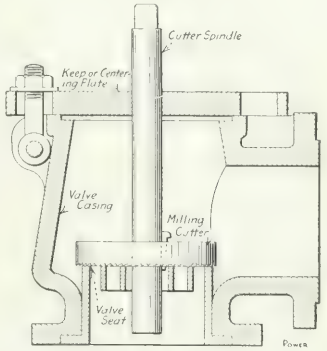
SHOWING CHANGE IN SUCTION PIPE

Valve Seat Grinding Tool

I was recently employed as chief engineer of a 2500-hp. plant having six water-tube boilers. I soon noticed that one of the boiler-feed pumps ran much too fast for the amount of water being evaporated.

One day I instructed my repair man to shut down the pump for examination and found the valves in good condition, but the composition valve seats were scored badly. The pump was of the pot-valve, duplex, outside-packed type, 10 and 7 by 10 in., taking water from an open heater at a temperature of about 190 deg. F. and pumping against 140 lb. boiler pressure.

After writing to the builders for prices on new seats I figured it would be an expensive job, so I took measurements and made a tool to reface the seats in place, which did away with the trouble. The accompanying sketch will give an idea of the tool and cutter.



VALVE SEAT GRINDER

A wheel was used for turning the spindle and cutter by hand. The guide piece across the top was drilled to fit the spindle closely and was held in place by the stud nuts. The tool cost about $8 and faced the valve seats good as new.

MILTON T. MONTEITH.

North Cambridge, Mass.

Peculiar Corrosion

On taking charge of a plant in a large mill, I found the boiler tubes leaking badly. Instead of leaking at the heads, which is usual in such cases, the water was issuing from the tubes along the sides. My suspicion of bad feed water had been aroused, as water left for some time in a tin can would turn the tin black.

Examination showed the tops of the tubes to be badly corroded, and in many places holes were eaten through the tubes; those eaten partly through showed the metal to be bright when the incrustation was removed. It was peculiar that the shell was only slightly affected while the tubes were seriously so.

A sample of the water, which came from a well and was very clear, was sent to a chemist for analysis. While awaiting a remedy new tubes were put in and finely powdered graphite put into the boiler. This seemed to prevent the corrosive action as the old tubes soon stopped leaking.

Will some reader explain why the tubes only were attacked seriously while the shell, except slightly along the water line, was unaffected?

JAMES W. LITTLE.

Fruitland, Wash.

Questions Before the House

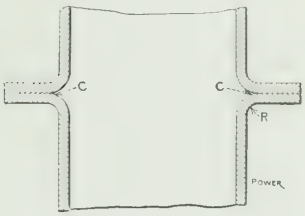
Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Reinforcing Van Stone Joints

In the issue of Feb. 27, Mr. Stevens compares the strain on the pipe and bolts in an 8-in. standard pipe with van stone joints.

To find the strain on the bolts due to the pressure it is necessary to use the area of a circle whose diameter is from *C* to *C* in the accompanying figures. With 1 in. radius at *R*, the circle is nearly 10 in. in diameter, and its area is 50 per cent. greater than the area of the pipe, and with 4000 lb. pressure per square inch it will give trouble. It is almost impossible to calculate these strains, and hence the details of pipe joints are much better determined by experience.

If experience shows that the bolts fail when the pipe is in line and expansion



SECTION OF PIPE AT JOINT

is taken care of, and the pipe does not vibrate excessively, it would be time to put in stronger bolts, but not because the factor of safety is only 10 in the bolts and 20 in the pipe. Personally I have not been troubled much by breaking bolts when these conditions were fulfilled.

The strains caused by lack of alignment are greater in the pipe than in the bolts as these bolts are farther from the center. The total strain in any pipe cannot be greater than enough to break the bolts, and strains due to expansion, vibration and lack of alignment are better taken care of in other ways than by making the system like the famous one-horse shay, when it fails all over if at all.

The standard weight of pipe was determined a long time ago and was made strong enough to have threads cut and still be strong. If a pipe is in line and expansion is provided for, it does not vibrate excessively. Why is not a factor of safety just as good in a pipe as in a boiler? It might not be good to use lighter pipe, but why use a factor of safety of more than 10 for the bolts and only 6 for the boiler?

HARRY D. EVERETT.

Fort Apache, Ariz.

Finding the Boiler Horsepower

In the issue of Mar. 19, mention is omitted of a most useful application of the supplemental chart. By means of this chart, it is possible to find accurately the boiler horsepower of a boiler making steam of any quality without reference to any other tables, and with but little calculation.

For instance, take a boiler evaporating 1000 lb. of water at 60 deg. F. per hour to steam, 95 per cent. dry, at 100 lb. gage, and let it be required to find the boiler horsepower. From the chart is readily obtained the factor of evaporation of 1.151. By multiplying this factor by 1000 the equivalent evaporation is had from and at 212 deg. F., which is equal to 1051 lb. per hour. This divided by 34.5 (the value of a boiler horsepower in pounds of water evaporated per hour from and at 212 deg. F.) gives directly 33.36 boiler horsepower, or

$$\frac{1.151 \times 1000}{34.5} = 33.36$$

The rule is as follows: To find the boiler horsepower multiply the factor of evaporation as found from the chart by the pounds of water evaporated per hour, and divide by 34.5.

LOUIS GROSSBAUM.

New York City.

Supplementary Exhaust Valves

In his criticism of my article in the Apr. 2 issue, Wendelin Sange states under the above title, that the engine would run poorly "if it would run at all," as "the pistons are far too short to cover the exhaust ports while the steam acts on the main piston."

I would call his attention to the fact that the size of the piston valve would entirely depend on the size of the port, the overthrow of the eccentric, and also, its angular advance. Since he did not specify the above in the case of his engine, he did not show that the length of the piston in my drawing is inadequate.

At any rate, my intention in the original letter was solely to show the means by which the reduction of the back pressure was accomplished; and my drawing was sufficiently clear to convey the intended information.

As to the data given by me on the age, speed, etc., of the engine, and reduction of back pressure, it was based on information received from Mr. Sange.

VICTOR BONN.

New York City.

Comment on Pressure Problems

In answer to Mr. Hawkins' first question, in the Mar. 26 issue, I say that when the gage has no pressure upon it the tube will be filled with air at the pressure of the atmosphere and when the pressure is turned on if the gage is connected to a siphon which will condense the steam, the water will advance into the tube as far as the air after being compressed will allow it. To illustrate: If the tube was 5 in. long and 100 lb. pressure would compress the air contained in this size tube into a space 1 in. long, then the tube would be filled with water for 4 in. of its length and with air for the remaining inch. This proportion would vary with the pressure for since there is no means for the air to escape it must fill part of the space in the tube.

If the gage was connected at the top of a vertical pipe filled with steam—which is the wrong way, since the heat would soon injure the tube—the air might take up slightly more space on account of its increased expansion; but there would not be much difference. This principle is illustrated in traps, radiators and any pipe having no way of circulating the steam.

For the second question, consider whether a gage placed at the end of 3000 ft. of ½-in. pipe would indicate the same pressure as one located on the boiler. It must be borne in mind that after the pipe is once filled with water there will be no flow except as the pressure increases, which will be so slow as to cause almost no perceptible friction, and as the area of the ½-in. pipe is at least four times that of the opening in the gage, there will be but little change in the pressure in that length of pipe; neither would it indicate a sudden change of pressure as quickly as the one at the boiler as the long body of water would move slowly. If there is nothing else connected to the pipe

but the gage there should be no perceptible drop in pressure.

As for the third question, it is found that the pressure available at this steam pressure would be about 277 lb. per square inch. Deducting the amount required to overcome the 10-ft. static head, there would be 277 lb. — 4.34 lb. = 272.66 lb. available.

Assuming a piston speed of 100 ft. per minute, the pump should deliver 293.8 gal. per minute, and deducting the 20 per cent. slippage, 235 gal. is being delivered into the pipe. According to the tables on friction loss in pounds per square inch, the loss for a flow of 250 gal. per minute through a 4-in. pipe is 1.89 lb. for every 100 ft. in length. If the pressure 272.66 lb. is divided by the loss per 100 lb. or 1.89, it will give 144.24, and this result multiplied by 100 will give 14,424 ft. of pipe necessary to overcome the pressure at the pump, but as the friction of liquids in pipes increases as the square of their velocity, there would be but a small amount of water delivered by the pump available at the end of the pipe, although theoretically, since the pressure is all taken up in friction, there should be no water flowing.

As water is incompressible there would have to be friction enough in this body of water to prevent the plungers moving at all, for if they did move the water would have to go somewhere, so that it would either burst the pipe near the pump or flow out at the further end.

G. H. KIMBALL.

East Dedham, Mass.

I say that the spring of a steam gage may contain either steam, water or air, but it should contain water. A well known steam-gage company states that "every gage used to indicate the pressure of steam should have a siphon or other device which will furnish water to and completely fill the tube springs to keep them cool."

A gage may be placed at any distance from a boiler and yet register correctly provided no steam is taken from the connecting pipe and there is no chance for water pockets to cause hydrostatic pressure. The 3000 ft. of ½-in. pipe, horizontal and closed, would give correct gage readings.

As the length of the horizontal discharge pipe is increased the pipe friction is increased up to the point where the static head plus the friction head balances the plunger slip. Again, the friction head is dependent on the condition that there shall be a flow of water, since if there is none there is no friction. Hence it would seem that the pipe cannot be made long enough to stall the pump, so there will always be a discharge from the pipe.

J. K. MCINTYRE.

Newburgh, N. Y.

The contents of the spring tubes in a steam gage depend entirely upon existing conditions; steam at ordinary temperatures may be allowed to enter and fill the spring while for high temperatures oil is often put in the siphon of the connecting pipe to prevent deterioration of the metal tubes. If the oil completely fills the spring, there is no air, of course, but undoubtedly there is usually some air caught above the oil. The spring may have air, or oil, or both, or steam inside it.

Both gages will show the same pressure, 100 lb., irrespective of the distance apart or the size of the pipe; static pressure is constant for a given level in any one system.

The third question seems absurd; if there is to be no discharge of the water there is no velocity; hence no friction. Also a pipe of infinite length would be necessary.

HUBERT L. WATSON.

West Lafayette, Ind.

[Many of our correspondents construed the third question submitted by Mr. Hawkins to mean a vertical instead of a horizontal pipe. Various vertical lengths have been given, ranging from 507 to 11,000 ft.

Fred. L. Wagner contends that the pressure in the discharge pipe which will balance the pressure in the steam cylinders is 277.77 lb.; that a pipe high enough to balance this pressure will be 277.77 lb. × 2.3 = 638.871 ft.

Arthur Scrivenor claims that if there were no slippage, the vertical pipe would be about 640 ft. high; that as the pump is of the outside-packed plunger type the slippage must be through the valves, but this slippage is not constant; hence the height of the column of water in the pipe would vary.—EDITORS.]

Mr. Clark's Diagrams

These diagrams, in the Mar. 19 issue, plainly indicate a broken bellcrank or stem on one of the steam valves; and probably a broken stem inside the stuffing-box or valve chamber, since any outside break would have been evident at once, and the taking of a diagram to find the trouble would have been unnecessary.

The right-hand diagram from the end with the broken stem shows that the valve stands wide open throughout the stroke. The loop to about one-half initial pressure at the end of the stroke is due to the opening of the exhaust valve, allowing the steam to blow through to the atmosphere. When the exhaust closes, the pressure rises to a little above initial pressure, due probably to the inertia of the steam in the supply pipe, which results in the loop at the top of the diagram.

The diagram for the other end shows the normal valve adjustment, but it is somewhat distorted, due to the steam blowing through the other end. This would account for the inclined steam line and the high back pressure.

The bottom line is the atmospheric line and should not be connected to the "toe" of the diagram as shown.

If Mr. Clark's engine exhausts to the atmosphere, and he had listened to it for a moment, he would have discovered what was wrong. I recently had a similar experience on a 26x48-in. engine which occurred in the early morning hours and created quite a disturbance.

F. P. READ.

Memphis, Tenn.

Connecting Rod Ends

Referring to Mr. Pullen's letter in the Mar. 5 issue, it is rare that the wear is equal enough to allow the same adjustment on both pins after one or two adjustments.

This is true because it is impossible to foretell how much each pin and its brasses are going to wear. As this type of rod requires the same amount of adjustment on each pin it is plain what the results will be.

The rod does, of course, work seemingly satisfactorily upon gas engines as there is little or no pressure upon the caps.

LLOYD V. BEETS.

Nashville, Tenn.

What the Diagrams Show

J. F. Reynolds, in the Mar. 26 issue, shows that the steam distribution in both cylinders is very good; the receiver pressure at first sight appears low when contrasted with the boiler pressure, but when it is considered that the low-pressure cylinder is, in round numbers, six times the volume of the cylinder, the reason for the apparently low receiver pressure becomes plain. I believe it is too high, for upon figuring the power developed in each cylinder, and using the mean effective pressure as given on each diagram, respectively, I find that the low-pressure performs more than twice the amount of work the high-pressure is doing. The powers are, 17.5+ for the high-pressure and 36 for the low-pressure. Of course, there may be a reason for the large difference in the powers; but unless there is a good reason for this difference, it seems to me that Mr. Reynolds can reduce his receiver pressure by an amount to cause a more nearly equal distribution of the work.

Cutoff occurs at about ⅛ stroke, which is too early for the best economy; and this seems to show that the engine is too large for the work it has to do, at the prevailing steam pressure; perhaps it would do better with a lesser boiler pressure.

CHARLES J. MASON.

Scranton, Penn.

While I think Mr. Reynolds' diagrams are very good and the compression is sufficient for such slow speed, the low-pressure cylinder is doing more than double the work of the high-pressure cylinder. If conditions will permit, the load ought to be more uniformly divided between the two cylinders.

WALLACE JOHNSON.

Utica, N. Y.

The indicator diagrams show a very good setting of the valves, the cutoffs being nearly equal for the two ends of the cylinders, and the mean effective pressures being about as nearly equal as it is practicable to get them. The distribution of work between the two cylinders, however, is a long way from equal, as the following computations will show.

Neglecting the areas of the piston rods, the diameters of which are not given, the results above are obtained.

Area of high-pressure piston	113 sq in.
Area of low-pressure piston	707 sq in.
Stroke of engine	2.5 ft.
I.hp., high-pressure head end $(113 \times 2.5 \times 34.25 \times 30) \div 33{,}000$	8.8
I.hp., high-pressure crank end $(113 \times 2.5 \times 34 \times 30) \div 33{,}000$	8.7
Total i.hp. for high-pressure cylinder	17.5
I.hp., low-pressure head end $(707 \times 2.5 \times 11.2 \times 30) \div 33{,}000$	18.0
I.hp., low-pressure crank end $(707 \times 2.5 \times 11.3 \times 30) \div 33{,}000$	18.1
Total i.hp. for low-pressure cylinder	36.1

There are two reasons why the power developed in the low-pressure cylinder is more than double that in the high pressure. First, the unusually large cylinder volume ratio, 6.25: 1, makes it difficult to get an equal distribution of the load when running at the light load indicated by the very early cutoff in the high-pressure cylinder. A decrease in volume of the low-pressure cylinder, the high-pressure remaining the same, would mean, for the same total indicated horsepower, a later cutoff in the high cylinder, and a more equal distribution of the work.

Second, the load can be partially equalized, by a decrease in the receiver pressure. This means, of course, a lower back pressure in the high-pressure cylinder, and therefore an increase in the mean effective pressure, and the mean effective pressure of the low cylinder will be correspondingly decreased.

A. L. WESTCOTT.

Columbia, Mo.

Injectors Will Not Work Properly

J. L. Brouse, in the Mar. 5 issue, asks whether both injectors erected as shown by his drawing would work at the same time in a satisfactory manner. I say they will not, because the two currents will butt each other and one or both injectors will break. Why not use only one injector of ample capacity, thus relieving the operator by one-half? If this cannot be done, connect them to a Y-fitting and there will be no trouble.

I also note that both injectors are operated from one outlet in the boiler; hence the boiler outlet should not be less than 2 in. if the steam inlet to the injectors are 1¼ in. in order to avoid the injectors breaking because of insufficient steam supply when both are in operation. If 45-deg. ells cannot be had, bend several pieces of pipe in order to get the injectors to stand horizontally.

WILLIAM S. LUCKENBACH.

Oakview, Penn.

Preventing Clogged Blowoff Pipes

Commenting on Mr. Amstutz's letter in the Mar. 12 issue, on "Cleaning a Clogged Blowoff Pipe," I suggest that he blow off his boiler every six hours; if the water is exceedingly impure, every four hours would not be too often. In this manner he can save himself much hard labor and never be troubled with a clogged blowoff pipe.

C. E. ALDRICH.

Mendota, Calif.

Who Broke the Crosshead?

Referring to H. R. Williams' crosshead accident mentioned in Mar. 26 issue, I believe that something got in between the end of the cylinder and the crosshead shoe, so that when it came in on the return stroke it struck the obstruction, breaking the crosshead. As the engineer had just packed the rod, preparatory to starting up for the night run, no doubt he was in a hurry, and unintentionally left a packing tool lying across the guide. In starting up the engine its vibration as it came up to speed jarred the tool until it fell into the hollow of the guide lengthwise. The crosshead hit the tool in this position, bending the adjusting bolt upward, and breaking the lower part of the crosshead. The buckling strain would then force the shoe and broken part out on the floor. Similar accidents have been known to happen.

L. M. JOHNSON.

Glenfield, Penn.

It is evident that there has been undue strain on the bottom shoe, and some extra friction must have caused the guides to heat; possibly the crosshead was too tight or the shoe came loose and the end cut into the guide.

I believe that it was too tight in the guides and when heated expanded the crosshead, and together with the working force (which force is on the lower guide when the engine is running over, and on the upper guide when running under) deflected the shoe, breaking it at the weakest point on the head end. As the extension on the main part of the crosshead was weak it broke also.

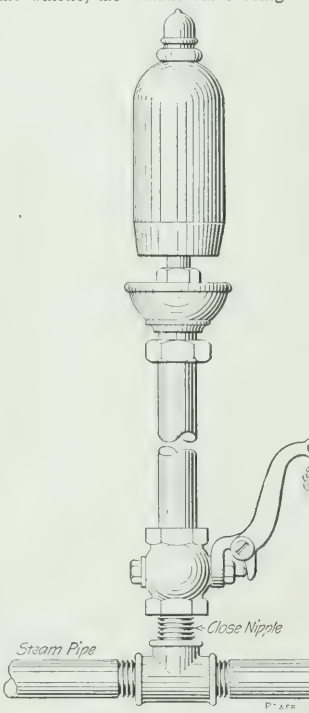
If the crosshead in the sketch is correct as to proportion, it looks to me as if the head end, where the break occurred, is of small cross-section when considering the cantilever load.

R. G. COX.

Milwaukee, Wis.

Whistle Connection

In reply to Harold Beecher's letter in the Feb. 2 issue, on drain for an exposed steam whistle, I wish to say that my whistle valve is located in the boiler room and the whistle is on the roof. My drain is attached to the steam pipe near the whistle, the whistle valve being connected with a close nipple to a steam pipe in which there always is dry steam, as, for instance, the pipe for the boiler feed pump. The arrangement is shown in the illustration.



WHISTLE CONNECTION

My whistle valve has a renewable disk, and whenever the valve starts to leak, the disk is renewed at the first opportunity. The valve and whistle have been connected as shown for 11 years and freezing has never occurred during cold weather.

H. A. JAHNKE.

Milwaukee, Wis.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Power Required to Pull a Load up an Incline

What power would be required to pull a load of 100,000 lb. up a one-mile incline in 10 minutes if the vertical height is 100 ft., and the resistance due to friction is 5 per cent. of the power required?

E. S.

The work required to raise the load to an altitude of 100 ft. would be

$$100{,}000 \times 100 = 10{,}000{,}000 \text{ ft.-lb.}$$

A horsepower is equivalent to 33,000 ft.-lb. Therefore the horsepower required would be

$$\frac{10{,}000{,}000}{33{,}000} = 303 \text{ hp.}$$

if the work were done in 1 min. But as 10 min. are required it will take one-tenth of this, or 30.3 hp. As the power required to overcome the friction is 5 per cent. of the total load, 30.3 hp. is 95 per cent. of it. The total load is

$$\frac{30.3}{0.95} = 31.895 \text{ hp.}$$

Reverse Current Steam Separators

What is the principle of a reverse-current steam separator?

J. G. B.

The direction of the flow is abruptly changed, usually through 180 deg. This causes the water in the steam, on account of its greater specific gravity, to be thrown into a receiving vessel, while the steam passes on in the reverse direction.

Auxiliary Heaters

How many square feet of heating surface per pound of water is considered good practice in an auxiliary heater?

H. P.

An auxiliary heater connected to the exhaust line of a condensing engine should have about 1 sq.ft. of heating surface of brass or copper tubes for every 60 lb. of water passing through the heater per hour.

Injector as a Boiler Feeder

Which is the most efficient, an injector or a steam pump, as a boiler feeder?

J. O'B.

With an injector the amount of heat taken from the boiler is returned to the boiler, less a slight loss due to radiation. From a heat-efficiency standpoint, it is nearly perfect. As a means of forcing water into the boiler it requires more steam than the most wasteful of pumps.

Speed Variation of a Corliss Engine

Does the speed of a Corliss engine change under full load?

J. McK.

A Corliss engine runs slower with full load. If it did not the governor balls would not run in the lower plane necessary for the later cutoff.

High Steam Pressures

What are the advantages and disadvantages of high steam pressures?

B. J. W.

High-pressure steam is advantageous because of the greater range of temperatures that can be utilized for power and their saving by reduced cutoff. Their disadvantages are: increased danger of rupture at the weak joints in the boilers and pipes, increased loss by radiation, decomposition of lubricants, increase of leakage, and larger cost of power plant to meet the increased pressure.

Brake Horsepower

What is the rule for obtaining the brake horsepower of a motor with a prony brake?

A. H. K.

Multiply the length of the lever from the center of the shaft to the center of the point of application to the scale, by the number of revolutions per minute, by the difference between the weight in pounds indicated on the scale when the brake wheel is in motion, and the weight indicated, when the wheel is at rest, and by 6.2832. Divide the result by 33,000, and the quotient will be the brake horsepower of the motor. Example: The speed of a motor is 960 r.p.m., the length of the brake arm from center to center is 12 ft. The weight of the arm indicated on the scale is 21 lb. and the weight indicated when the motor is running is 72 lb. Substituting figures, the rule would be expressed as follows:

$$\frac{6.2832 \times 12 \times 960 \times (72-21)}{33{,}000} = 111.8 \text{ b hp.}$$

Total Heat of Saturated Steam

In a recent issue of POWER, the total heat of steam above 32 deg. F. at 105 lb. absolute was given as 1187.2 B.t.u. Is this correct? The table which I use gives it as 1182.9 B.t.u.

S. J. C.

The value 1187.2 B.t.u. for the total heat of steam of 105 lb. absolute is from the Marks-Davis tables. Prof. Peabody's revised tables give it as 1186.9, the difference being due to the inclusion in the Marks-Davis tables of the heat equivalent of the feed-pump work and to Prof. Peabody's use of 778 ft.-lb. as the mechanical equivalent of heat, while Marks-Davis use 777.52 B.t.u. Prof. Peabody uses the heat required to raise a pound of water between 62 and 63 deg. for his thermal units, while Marks-Davis use the average heat required to raise a pound of water 1 deg. between 32 and 212. The values given by the older tables are too low. See paper by Dr. Davis, A. S. M. E., Proc. Vol. 30, 1908.

Per Cent of Moisture in Steam

What would be the percentage of dry steam and moisture if, when using a separator calorimeter, the weight of dry steam was 13 lb. and the weight of water obtained was 9.2 oz.?

C. B. M.

Divide the weight of dry steam by the sum of the weight of the steam and the water, and multiply by 100. Both quantities must, of course, be expressed in the same units. 9.2 oz. = 0.575 lb. Then for your case

$$\frac{13}{13 + 0.575} = 0.958$$

or 95.8 per cent.

Load Factor of Engine

What would be the load factor if an engine rated at 125 hp. was developing 126.25 hp.?

C. J. B.

The engine would be developing

$$\frac{126.25}{125} = 101 \text{ per cent.}$$

of its rated capacity. This is sometimes referred to as the load factor, but the term is more frequently used, especially as applied to a station, to express the ratio of the average to the maximum load.

Brownhoist Suspended Bin

The Brownhoist patent suspended bin, an installation of which is shown in Fig. 1, is designed for storing coal, ashes, coke, sand and other materials in bulk, and its construction is such that the material forming its sides and bottom utilizes its tensile strength to resist the strains set up by the load.

This bin consists essentially of two plate girders supported by columns or side walls, usually by columns, as shown in Fig. 2. The girders are inclined from the vertical so as to make the straps and the outside of the bin tangent to the forced-concrete lining acting as a beam between the straps.

In lining a bin with a "ferroinclave" reinforced-concrete construction, a wooden strip about ⅜x1 in. wide is first placed on the inside of the curved straps and made to conform to the contour of the straps. The "ferroinclave" sheets are then placed on these strips and are secured to the straps with small bolts. The sheets are shingled at each lap, which makes practically a continuous member the whole length of the bin, and by reason of being able to shingle the sheets at the laps only one line of bolts is required to each strap.

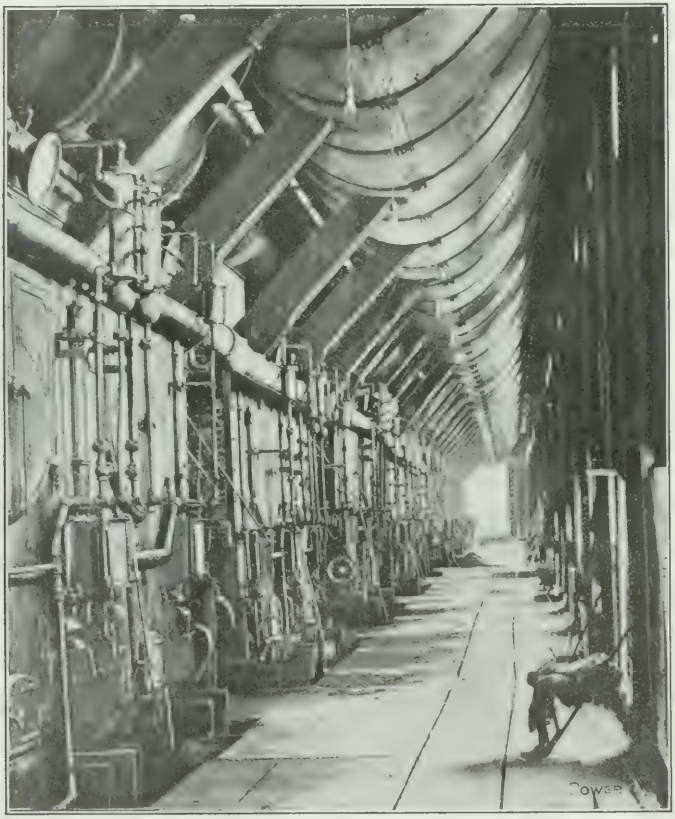


FIG. 1. AN INSTALLATION OF BROWNHOIST SUSPENDED COAL BINS

girder. At intervals of from 3 to 5 ft., depending on the load to be supported, steel straps, which are parabolic in shape, are hung from these girders. The straps are made strong enough to carry the weight of the reinforced-concrete lining and the material to be stored in the bin, and are shipped straight and formed to shape in erection and then riveted to the lower side of the beams. The entire weight to be supported is concentrated in these straps by reason of the rein-

When the "ferroinclave" is in place the upper side is coated with a mixture of one part of portland cement to two parts of sand, or with a mixture of one part portland cement, two parts sand and four parts broken stone, all stone to pass a ½-in. mesh. The thickness of this lining varies with the span and loading, allowance being made for wear, which is generally about 1 or 1½ in. The thickness of the concrete on the inside of the bin generally varies from 3 to 4½ in. at the bottom and gradually tapers to about 1 or 1½ in. at the top of the bin. When the inside cement has set it appears as shown in Fig. 3. The under side of the "ferroinclave," shown in Fig. 4, is then coated with a mixture of one part of portland cement and two parts of sand with the addition of a small amount of goat hair. The mixture is pushed in between the straps and the "ferroinclave" so as to solidly fill the ⅜-in. space made by the wooden strips, which practically gives a ⅜-in. coating on the outside of the "ferroinclave."

In lining the inside of the bin enough open reinforcement is included to cover the girder and any other exposed places that would come in contact with the stored material. This reinforcement is secured to the girder by a special clip. In this way the girder is completely protected from the corrosive action of the material in the bin. Generally, steel plate linings are protected from corrosion by a coating of portland-cement mortar 1 to 2 in. thick and secured to the plate by wire netting and clips.

The ends of the bins are usually made by fastening angle clips onto the last strap and connecting I-beams or channels to these clips to act as struts that run horizontally across the end to give the necessary required strength to resist the component forces from the load in the bin. A ⅜x3½-in. wooden strip is then laid along the inside of these struts and the "ferroinclave" sheets laid on these wooden strips and fastened to the struts. The sheets are then concreted on the inside to a thickness of between 3 and 4½ in. at the bottom, depending on the load in the bin, and tapered to about 1 or 1½ in. at the top, similar to the concreting of the siding of the bin. After the concrete has set, the outside is then concreted similar to that described for the side of the bin.

These bins are made in capacities ranging from 1 to 15 tons per lineal foot. The bin can be used in almost any plan for, on account of its peculiar shape, can be designed to the capacity requirements and still be placed in the boiler room without occupying valuable space in front of the boilers.

This bin requires practically no repair as the concrete lining is noncorrosive and fireproof. The exposed parts, such as the gates, chutes and spouts, can be easily removed without destroying the concrete lining in any way. The bin is self-emptying, and in many cases a concrete housing is carried up to the roof thereby making an almost dustproof boiler room.

Practically any form of chute can be used in connection with the bin, but the special chute is made, the main advantage of which is that it can be locked open or shut by virtue of its toggle mechanism. The gates of the chute are op-

erated from the floor by a hand chain, and the coal is delivered centrally on both gates, which open simultaneously. This is shown in Fig. 5. The spades and chute casting are constructed so as to thrust large pieces of material either in or out without jamming.

The chutes are connected to spouts of which there are several designs. One of the designs is to be used in connection with a line of stokers on one side of the bin only and has at the bottom of the spout a spreader or distributor placed to get the proper distribution of coal on the bunker. A straight spout without any spreader at the bottom is also made, but is pivoted to the chute at the top so that it can be moved across the face of the stoker while the coal is being fed.

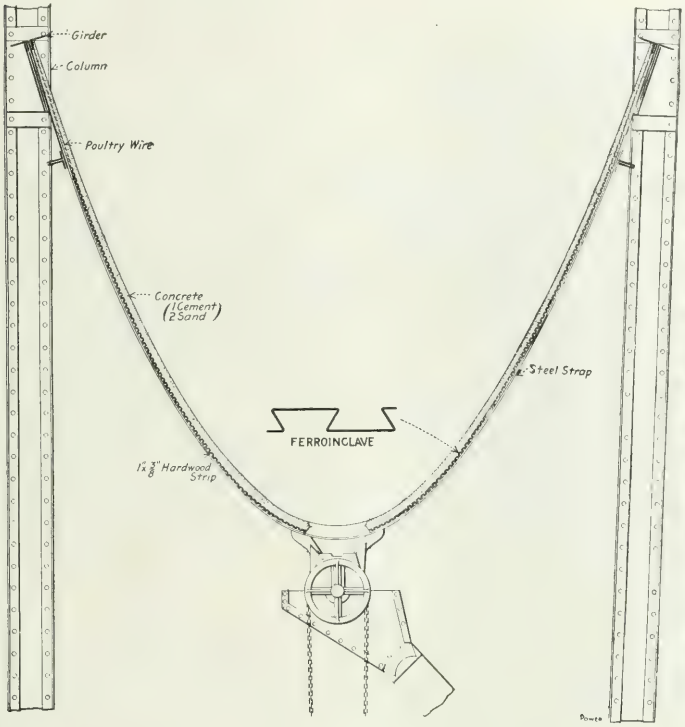


FIG. 2. DETAILS OF CONSTRUCTION

For installations where the boilers and stokers are on both sides of the bin a straight spout is used without a spreader at the bottom and so designed that it can be swung from one stoker to the other that is directly opposite it; thus a single spout and chute can be utilized to supply the coal to two stokers, thereby eliminating the expense of the extra mechanism. To feed the stokers in this design the spout must be moved across the face of the stoker while the coal is flowing. Another style of spout is frequently used, although it is somewhat more expensive than the one just described, inasmuch as each stoker has its separate chute and spout. To accomplish this the location of the chutes are staggered so that they come between the stokers instead of opposite them, which is the usual way, and the spouts are then designed on an angle so as to bring the orifice in the center of the stokers. These spouts have a spreader at the end to give an equal distribution of coal.

In connection with these chutes a line of stationary and movable hoppers are manufactured in which the coal can be accurately weighed and, if necessary, recorded before being fed to the stoker.

This bin and attachment are manufactured by the Brown Hoisting Machinery Co., Cleveland, Ohio.

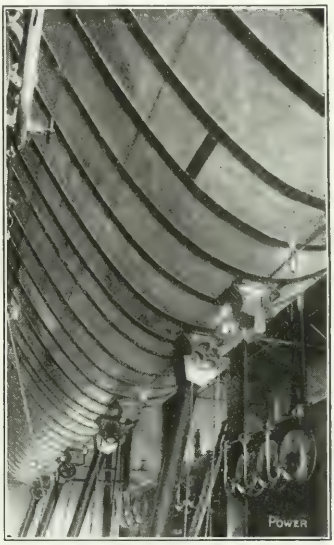


FIG. 5. GATES TO BIN

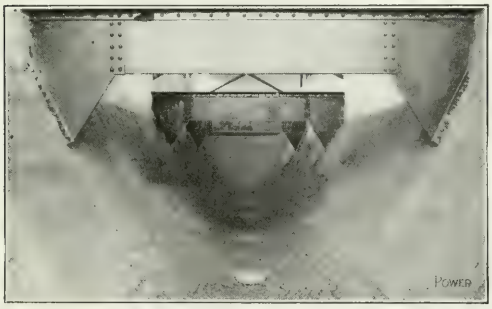


FIG. 3. CEMENTED INTERIOR OF BIN

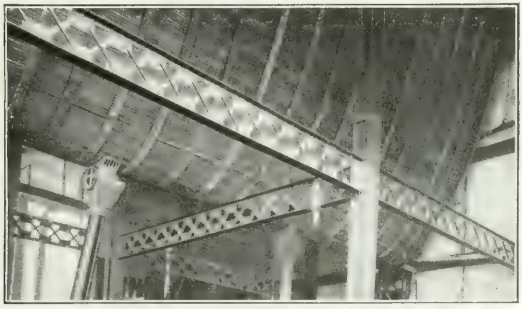


FIG. 4. EXTERIOR OF BIN BEFORE APPLYING CONCRETE

San Antonio Locomotive Boiler Explosion

The accompanying illustrations show the condition of the outside sheet of the firebox of the locomotive boiler which exploded at San Antonio, Tex., Mar. 18, an account of which was published in the Apr. 9 issue.

The 6-ton sheet, shown in Fig. 1, was hurled through the air nearly a quarter of a mile. It is an interesting study, as it shows the condition of the stay-bolts and broken sling stays. It will be noticed that the former pulled out of the fire sheets, remaining in the outside sheets, or were broken off, leaving portions of the stay-bolts in both sheets. The photograph indicates that less than 60 stay-bolts pulled out of the outer firebox sheets.

The bird-shaped plates, illustrated in Fig. 2, are the same as shown in Fig. 1, but in a different position.

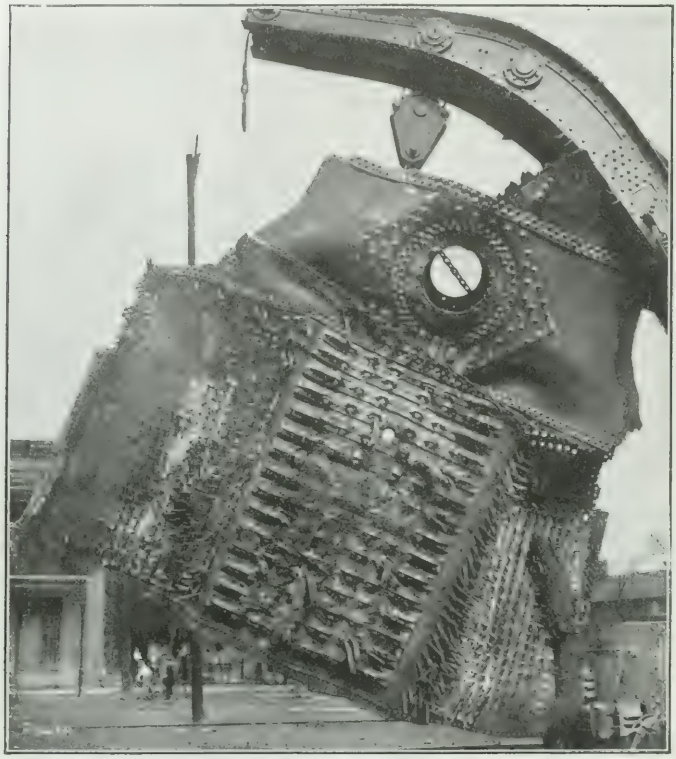


FIG. 1. OUTSIDE SHEETS OF THE FIREBOX SHOWING STAY-BOLTS AND BROKEN SLING STAYS

Boiler Explosion Wrecks Factory

By the explosion of a boiler in the S. A. Wellman handle factory, at South Boardman, Mich., on Apr. 5, the engineer was killed and five other employees were injured.

The accident took place at the noon hour; the engineer was eating dinner in the fire pit in front of the boiler when without warning the boiler burst, hurling him against the side of the building, then covering him with hot bricks and burning timber. Both legs and one arm were broken, his back wrenched and he was badly scalded. He died shortly afterward.

Portions of the boiler were found several hundred yards away. The scattered ashes and sparks set fire to the ruins; and two of the men would have been cremated if they had not been promptly rescued. The cause of the explosion is unknown.

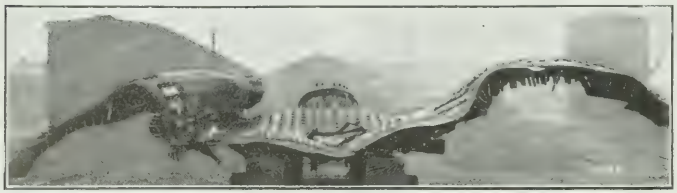


FIG. 2. OUTER FIREBOX SHEETS SO BENT AS TO RESEMBLE A HUGE BIBD IN FLIGHT

Boiler Explodes at Orilla, Wash.

A 100-hp. boiler in the Orilla Lumber Co. plant exploded at Orilla, Wash., on the morning of Apr. 10. Though the boiler and engine room were wrecked, the blacksmith's shop near-by was crushed by a heavy piece of boiler plate, and six persons were standing in the immediate vicinity, no one was fatally injured.

The dynamo and engine were also wrecked and the roof was lifted off the mill. No cause is known for the explosion, the press reports offering the usual surmise that the water was low in the boiler.

Receivership for Allis-Chalmers Co.

On Apr. 6 receivers were appointed for the Allis-Chalmers Co., in the persons of D. W. Call, president of the company, and Gen. Otto H. Falk, president of the Merchants and Manufacturers' Association, of Milwaukee.

While no statement could be obtained from the company, the receivership has in all probability been declared as a means to facilitate the early reorganization of the company, details of which have been given in recent issues.

The receivership will fully protect all parties dealing with the Allis-Chalmers Co., and guarantees the prompt fulfillment of all outstanding and future contracts, and there will be no cessation of activity in any line.

A Convenient Chart

The De Laval Steam Turbine Co., of Trenton, N. J., has recently got out a convenient form of the Mollier diagram accompanied by a measuring scale by which the desired quantities can be read off directly. By means of the scale it is possible to determine readily the B.t.u. theoretically available per pound of expanding steam, the resultant velocity of the steam, the steam consumption of a perfect engine operating between the given limits and the duty in million foot-pounds per thousand pounds of dry steam. The chart may be had upon application to the company.

Sale of Condemned Equipment at Brooklyn Navy Yard

Sealed proposals are invited by the government for the purchase of the condemned stores at the Brooklyn Navy Yard, the sale of which will take place on May 27.

THE MEMBERS OF THE BAVARIAN TECHNICAL MUSEUM COMMISSION

(From a photograph taken on board the "Amerika" on arrival, reproduced by courtesy of the New York "Staats Zeitung.")

Reading from left to right: Mr. Orth, Civil Engineer; Dr. Ross, Secretary of the Commission; Dr. von Borscht, Mayor of Munich, Privy Councillor; Dr. Fuchs, Civil Engineer; Count von Podewils-Durniz, President of the Museum, former Prime Minister of Bavaria; Mr. Trautwein, Civil Engineer; Dr. Oscar von Miller, President of the German Society of Engineers and Professor in the Munich Polytechnic; Mr. Gelius, Architect to the Commission; Prof. Dr. von Dyck, Rector emeritus, Technical University of Munich.

Among the machinery to be sold are condensing engine-driven air compressors, intercoolers and receivers, McIntosh-Seymour cross-compound condensing engines, Westinghouse 220-volt generators, Blake plunger pumps, feed-water supply tanks, hotwell tanks, power-plant piping, traps, fittings, headers, complete electrically driven elevator equipments, etc.

Schedules containing the full particulars, form of proposal and terms of sale may be obtained upon application to the Paymaster of the Navy Yard.

The German Industrial Museum

On Tuesday evening, Apr. 9, Dr. Oscar von Miller, director of the industrial museum at Munich, presented to the American Society of Mechanical Engineers, at New York, a paper illustrated by lantern slides upon the museum and its work. Photographs of many of the more interesting exhibits and those illustrating the methods of presentation and demonstration of various subjects and processes were thrown upon the screen.

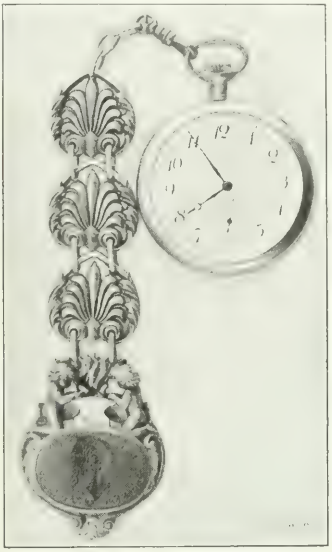
The lecture was followed by the presentation by Dr. W. von Dyck of the biography, written by himself, as a part of the museum's activities, of the eminent German chemist Karl von Reichenbach, and by a reception in the rooms of the society.

The occasion was an advantage taken of the presence in this country of the Commission of the museum whose photographs, taken upon their arrival, are shown herewith. They will study industrial and museum methods as followed here and it is hoped that their visit may inspire interest in the establishment upon this side of the water of a museum to preserve the history of our industrial development to exemplify its processes and exhibit its products.

Dr. Denton Honored by Mechanical Engineers

The alumni of Stevens Institute of Technology recently paid a tribute to the mechanical genius and strong personality of Dr. James E. Denton, who has long been associated with the institute faculty. He has been forced by impaired health to retire from the activities of his profession as engineer and teacher, and the alumni seized upon the occasion to present him a token of love and esteem in the form of a watch and fob accompanied by an engraved testimonial containing the signatures of a majority of the alumni and the professors.

Dr. Denton has gained a world-wide reputation in steam engineering. In 1906 the degree of doctor of engineering was conferred on him, and he has, therefore, the distinction of being the first Stevens alumnus to receive this degree from his college. He was graduated in 1875.



WATCH AND FOB PRESENTED TO DR. DENTON

Accompanying the gift was a description of the symbolic significance of the watch and fob, which are the work of F. Walter Lawrence, a well known goldsmith of New York City.

Modern Science Club's New Officers

The annual election of the Modern Science Club was held on Tuesday evening, Apr. 9, in the club house, at 125 South Elliott Pl., Brooklyn, N. Y. The following officers and directors were elected for the ensuing year:

President, John P. Bonney; vice-president, C. H. Haggerty; treasurer, George O. Kaley; financial secretary, J. W. Sterrett; secretary, John P. Martin.

Board of directors: E. G. Gennert, Frank Martin, J. H. Baumann, William Smith, W. G. Freer, F. J. Wood, J. A. Donnelly, H. A. Forward, George A. Diack, H. J. Murphy.

National Heating Association Convention

The National District Heating Association will hold its fourth annual convention in Detroit, Mich., June 25, 26 and 27.

The progress of the convention will include an address of welcome by the

mayor of Detroit, and Alexander Dow, of the Edison Illuminating Co. The following papers will be read: "Common Sources of Trouble in Customers' Installations," W. E. Darrow, Merchants Light, Heat & Power So., Indianapolis, Ind.; "Quality of Steam as Served by Central Stations to Their Customers," A. C. Shepherd, Cleveland Electric Illuminating Co., Cleveland, Ohio; "An Analysis of Heating Rates," A. E. Duram, Central Station Engineering Co., Chicago, Ill.; "Heating in Connection with Curtis Steam Turbines," August H. Kruesi, General Electric Co., Schenectady, N. Y.; "Description of a Combined Steam Heating, Ice Making and Electric Power System," J. T. Lewis, manager, Murphy Heating Co., Detroit, Mich.; "Description of a Large Hot-water Heating System," G. E. Chapman, Public Service Co., Chicago, Ill.; "De-centralized Steam Plants," S. M. Bushnell, Chicago, Ill.; "Depreciation in Underground Distribution Plants," W. Jennings, Harrisburg Steam Heat & Power Co., Harrisburg, Penn.; "Economic Survey of Combined Power and Heating Systems," E. D. Dreyfus, Pittsburg, Penn. The committees on rates and central-station records will make their reports, and a description of underground insulation, by a number of manufacturers of such insulation, will be given.

The entertainment for the convention will include an auto ride for the ladies on Tuesday afternoon; a theater party at Temple Theater on Tuesday evening; Wednesday afternoon a boat trip to the Flats, with the afternoon session on the boat and supper at the Flats; for the ladies, on Thursday morning, a card party.

The association has charge of the exhibit hall and arrangements for space at the exhibit should be made directly with the secretary. The headquarters will be at the Hotel Cadillac, and reservations for rooms should be made directly with the hotel. All inquiries regarding the convention should be directed to D. L. Gaskill, secretary, Greenville, Ohio.

Philadelphia Asks Aid of I. O. E.

That the city of Philadelphia is anxious to have the Institute of Operating Engineers assist in its department of public works, is evidenced by the recent request of officials of the city to that effect. President J. C. Jurgensen visited the different power plants of the department of public works of that city in February.

The public officials of Philadelphia hope to so arrange matters that the Institute of Operating Engineers diploma will be credited as equivalent to a certain percentage on any civil-service examination paper. Should this be carried through, it will constitute a recognition as yet given to no engineering society and will be an authoritative indorsement to the work of the institute.

Cleveland's "Engineers' Day"

The success of the picnic and outing, held last year under the auspices of the Combined Engineers' Associations of Cleveland, at Luna Park, has encouraged its promoters to make even greater efforts for this year's event, which will take place on July 20, in Luna Park.

There will be the usual games, contests, drawings, etc., and the joint executive committee, composed of three delegates from each of the local engineers' organizations, is already actively engaged in planning new attractions.

Seattle Convention of the N. E. L. A.

Arrangements for the coming National Electric Light Association convention at Seattle, Wash., in June are well advanced, and the officers and committees held a meeting on Apr. 5, at Minneapolis, to report on their work.

In an early issue will appear an outline of the work to be done at the meetings and the list of papers to be read, as well as the preparations that have been made for the visiting members' entertainment.

SOCIETY NOTES

The 1912 annual meeting of the American Association of Refrigeration will be held in Washington, D. C., on May 6 and 7. The sessions on May 6 will be held at the New Willard Hotel and on the seventh at the Bureau of Standards, where lucheon will be served. Further particulars as to the program and questions to be considered at the meeting will be announced at an early date. It is hoped that final action on the plans for the Third International Congress of Refrigeration may be taken at this meeting.

BOOKS RECEIVED

ALTERNATING-CURRENT DESIGN. By Julius Frith. D. Van Nostrand Co., New York City. Cloth; 118 pp., 5¼x8½ in.; illustrated. Price, $2.

ASSOCIATION EDUCATIONAL WORK. By George B. Hodge. Association Press, New York. Cloth; 256 pp., 5x8 in.; fully illustrated. Price, $1.

THE ELEMENTS OF STRUCTURES. By George A. Hool. McGraw-Hill Book Co., New York. Cloth; 188 pages, 6x9 in.; 143 illustrations; indexed. Price, $1.75.

MECHANICAL EQUIPMENT OF FEDERAL BUILDINGS. By Nelson S. Thompson. Williams & Wilkins Co., Baltimore, Md. Cloth; 277 pp., 5¾x9 in.; charts. Price, $2.

ELEMENTARY MECHANICAL REFRIGERATION. By F. E. Matthews. McGraw-Hill Book Co., New York. Cloth; 172 pp., 6x9 in.; illustrated; tables. Price, $2.

REFRIGERATION, COLD STORAGE AND ICE MAKING. By A. J. Wallis-Taylor. D. Van Nostrand Co., New York. Cloth; 632 pages, 5½x9 in.; 414 illustrations; tables; indexed. Price, $4.50.

NEW PUBLICATIONS

STEAM POWER PLANTS; Their Design and Construction. By Henry C. Meyer, Jr. Published by McGraw-Hill Book Co., New York, 1912. Size, 5¾x9 in.; 219 pages; 88 illustrations, including 21 large-size plates; cloth. Price, $2, net.

This is the third edition of this book, rewritten and enlarged. The original work is so widely and favorably known that to say that the present edition is good amounts to sheer redundance.

Shortly after the first edition was published, in 1902, the author gave up the editorship of the *Engineering Record* and began to practice as a consulting engineer for power-plant design and construction. The experience thus gained, he says in the prefatory note to the present issue, led him to make some changes and many additions when he came to the work of revising the book. The chapter on steam turbines has been added, also much new matter on the subjects of steam piping, condensers and chimneys. In addition to these subjects, the book contains two chapters on steam boilers, their proportions, design, selection and erection; two on the selection of engines, dimensions of the cylinders, speed, steam pressure, general specifications, etc., and one chapter each on condensers and pumps, feed-water heaters and economizers, mechanical draft, and coal handling, water supply and purification.

This book should be especially valuable to all who are not professional designing engineers and who may have occasion to lay out a new plant, remodel an old one or purchase and install any pieces of power-plant equipment.

PERSONAL

Irving H. Reynolds, who was formerly chief engineer of the Allis-Chalmers Co., and later with the William Tod Co., of Youngstown, Ohio, has again entered the employ of the former company.

Frederick S. Palmer, well known as an expert in his line, has assumed the position of general manager of the automatic engine-stop department of the Metallic Packing & Manufacturing Co., Elyria, Ohio.

Mancius S. Hutton, Jr., has just become associated with Frederick A. Hall in his engineering and sales offices at 5 to 9 Beekman St., New York City. Mr. Hutton, who is the son of Prof. Frederick R. Hutton, honorary secretary and past-president of the American Society of Mechanical Engineers, will give special attention to the departments of boilers, engines and power equipment in which Mr. Hall acts as the direct representative of manufacturers.

POWER

Vol. 35 NEW YORK, APRIL 30, 1912 No. 18

THE person who, without permission, will walk by the "No Admittance" sign at the entrance to an engine-room is on a par with the fellow who reads the "Fresh Paint" warning and then deliberately jabs his thumb into it to prove it. Signs mean little to him.

Not long ago, during the temporary absence of the engineer, a representative of an electrical company, who had been sent to make minor repairs, walked past the "No Admittance" sign at the door, and proceeded, without permission, to work on the three-wire-generator which was in operation.

In some unknown manner, he dropped a metal case between the commutator and collector rings. Instantly the machine emitted a volume of sparks. Bewildered, the trouble-maker started to open the individual circuits, instead of throwing the main circuit-breaker and also reducing the voltage until the engine could be stopped.

The engineer soon arrived, and after shutting down, he demanded to know what the intruder meant by ignoring the sign at the door.

"If you had obeyed that sign, you would have waited until I returned, and all the trouble your carelessness has caused me could have been prevented."

The following case illustrates where another engineer insisted on the observance of the "No Admittance" rule: While Old Herman, who always worked the 12 midnight to 8 a.m. watch, was absorbed in reading his report, he suddenly looked up and saw a well groomed intruder closely scrutinizing the switchboard.

Herman shouted at him: "Hey, you, git oudt of here! Didn't you see dot sign at der door?"

"Yes," smilingly answered the gentleman.

"Vell, for why you didn't pay no attention by it? For why you didn't ring der bell?"

"Apparently you do not know who I am. I'm Mr. Blank, the general manager."

"How do I know you are? I'm here to enforce der rules, undt I'm going to do it. Git oudt anyway!" retorted Herman, as he ushered the visitor out and slammed the door.

"Vell," muttered Herman, as he resumed his reading, "if he's Mr. Blank I may be fired in der morning; but rules is rules."

Contrary to Herman's fears, the manager was pleased to know that he had a man who fearlessly obeyed orders and executed them to the letter.

If you have been hitherto negligent in enforcing this rule in your plant, now is the time to polish the old sign and also install a call bell, and see that it is used by outsiders seeking admittance to the plant. Those having business with the engineer are no more privileged to walk by the "No Admittance" sign than they are to crowd by the boy in the president's office when seeking an interview.

Small Chinese Power Plant

By Walter H. Adams*

An uptodate plant, the equipment of which was collected in four different countries, supplying light, heat and power to the buildings of the Imperial Pei-Yang University. A water purification plant and pumping station is also installed.

*Professor of mechanical engineering, Imperial Pei-Yang University, Tientsin, China.

The Imperial Pei-Yang University is situated on the bank of the Pei Ro (North River) about five miles north of the foreign settlements of Tientsin and two miles from the native city. On three sides it is surrounded by open fields and on the fourth by the river.

The companies operating the lighting and water systems of Tientsin would not extend their service to the university owing to the distance and the small remuneration that could be expected; hence the university authorities decided to install a plant of their own for supplying light, heat, power and water. This was completed in 1910 and is interesting chiefly because of its component parts and its location, rather than its size.

FIG. 1. GENERAL VIEW OF PLANT

The apparatus was collected from the United States, England, Germany and China, and was installed by Chinese workmen under the supervision of American and German engineers. The university being five miles from a railroad and in a country where there are few facilities for moving heavy machinery, the apparatus had to be delivered partly by boat and partly by carts drawn by coolies. In selecting the equipment, cheapness was not the first consideration, but rather its adaptability for testing purposes.

The present equipment consists of two Babcock & Wilcox boilers; two Buffalo Forge Co.'s engines direct-connected to two 110-volt 15.5-kw. Siemens-Schuckert generators; a storage battery, with booster; an indirect heating plant for the main building of 25 rooms, and a steam pump, air compressor and motor-driven centrifugal pump for the water system, together with the usual auxiliaries.

There are over 40 buildings to be supplied with light and water, and the power house is placed in a central position with the apparatus for the water system beside it. Fig. 1 is a general view of the plant.

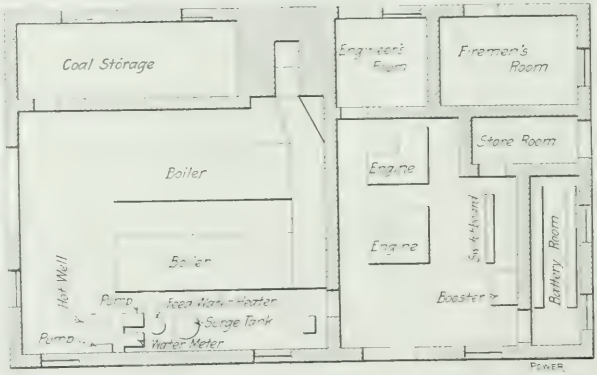


FIG. 2. PLAN OF BOILER AND ENGINE ROOMS

WATER SYSTEM

The river water is pumped by a motor-driven centrifugal pump having a capacity of 265 gal. per minute, through a 3-in. pipe line 800 ft. long to the sludge well. Here it passes from the bottom to the top of the well through a screen of copper netting. At the top it flows to one of two settling tanks, and after settling for one day it flows to the sand filters. There are two of these sand filters, shown at *A*, Fig. 1, which are used alternately every month. From the filter the water flows by gravity to a concrete storage tank *B*.

The water is pumped from the storage tank by a single-cylinder steam pump, located in pump house *C*, into a steel pressure tank *D*, partly buried in the ground. This tank has a capacity of 20,000 gal. and an air pressure of 35 to 40 lb. per square inch is maintained within it.

A direct connection between the storage tank and the pressure tank is provided for use in case the main steam pump breaks down. In such a case the pressure on the steel tank is removed and water will flow into it by gravity. After the water level in the two tanks is the same the valve between them is closed and the pressure is produced by pumping air with the air compressor. On the other hand, if the air compressor breaks down, pressure can be maintained on the system by the main steam pump.

The distribution system is laid under ground, and hydrants are provided for use in case of fire. When a fire does occur the pressure tank is cut off from the distribution system and the main pump is used to produce a water pressure of 80 lb. per square inch.

The maximum capacity of the system is 50,000 gal. per 24 hours, which is determined by the amount of water that can pass through the filters properly.

A plan of the power house is shown in Fig. 2. The boilers are not placed in a battery as they were installed at dif-

erent times. At one side of the boilers s a coal bin of 40 tons capacity, which s supplied through two windows from a latform outside. The coal is brought n bags weighing 200 to 250 lb. each, vhich are transferred from the carts to he bin by coolies.

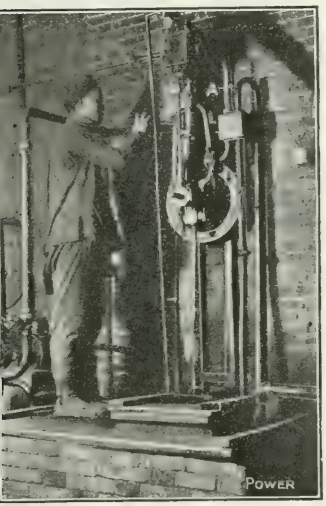


FIG. 3. FEED PUMPS

BOILERS

The boilers, which are of the standard Babcock & Wilcox type, were made in Glasgow, Scotland. Each is rated at 1600 lb. evaporation per hour and has 576 sq.ft. of heating surface. The working pressure carried is 110 lb. gage. It may be interesting to know that the safety valve is of the spring pop type with a lock on the spring, for when a Chinese fireman cannot keep his pressure up he ties down the safety valve, if possible, and then proceeds to make as large a fire as possible.

Bituminous slack costing about $1.75 a long ton is used, but owing to poor quality and poor firing, the average evaporation is only about 4 lb. of water per pound of coal. Each boiler is cleaned once every two months and, as a rule, no trace of oil is found and there is only about $\frac{1}{32}$ in. of very soft scale. This is easily removed.

Two feed pumps are installed, shown in Fig. 3. One was made by Alexander Young & Co., Ltd., of London, and is of the vertical, flywheel type, and attached to it there is a single-acting home-made pump placed below the water level in the hotwell. The bottom of the hotwell is 9 ft. below the boiler-room floor so as to receive the returns from the heating system.

A Eureka duplex steam pump is provided for use in case of a breakdown of the main feed pump. As it is placed above the level of the boiler-room floor it can pump only cold water.

The feed water is pumped through a Worthington meter and then passes to a closed heater.

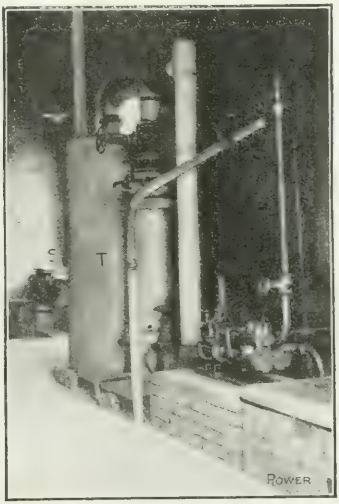


FIG. 4. SEPARATOR AND SURGE TANK

The exhaust steam passes through the oil separator (*S*, Fig. 4), which is of German make and consists essentially of a baffle-plate with an oil- and water-separating tank attached to the drip. Sufficient cylinder oil is saved to lubricate the pumps. The steam next passes to a 30-in. surge tank (Fig. 7), connected to which are the feed-water heater and the pipe leading to the heating system. An atmospheric exhaust is also provided with a back-pressure valve.

ENGINES

The main units (Fig. 6) are 8x8-in. single-cylinder, center-crank, high-speed engines direct-connected to the generators, and run at 350 r.p.m. An interesting thing about the engines is the fact that the generators and engines were never put together until they were placed on the foundations in the power house. The entire base was sent from America and the generator fields, outboard bearings and armatures came from Germany. These fitted exactly on one engine and the other merely required a little chipping and filing before fitting properly.

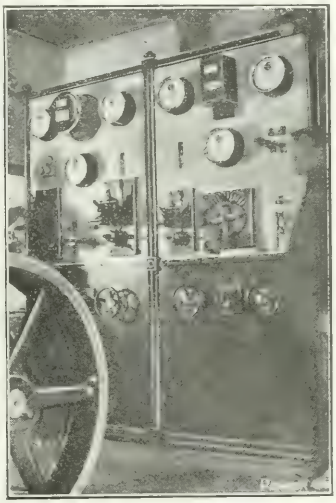


FIG. 5. SWITCHBOARD

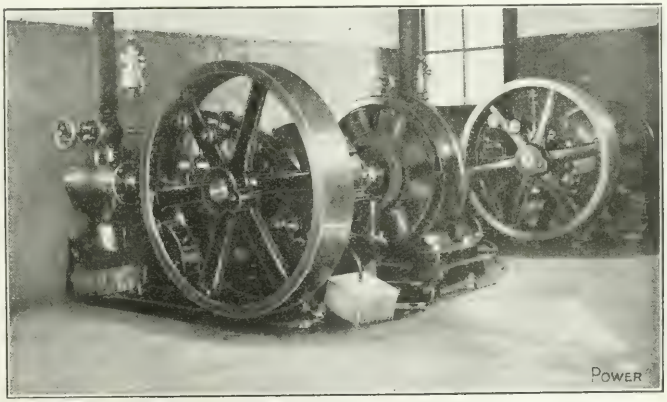


FIG. 6. MAIN GENERATING UNITS

ELECTRICAL EQUIPMENT

The plant has a storage battery of German make which supplies current during the day and after midnight. The

battery consists of 62 cells and has a total capacity of 54 amperes for 3 hr., or an ampere-hour capacity of 162. The charging is done through a booster set. The entire control of the storage-battery voltage and the booster set is from the switchboard. The last 13 cells of the battery are used as regulating cells and

ing made double in order to hold a high-pressure steam pipe that supplies steam to the laboratories. The two pipes are covered with poultry netting which is then plastered with a mixture of lime and graphite. The pipes have a slope of 1 in. in 10 ft. away from the power house.

and an automatic and hand air valve. The condensation passes through a trap into the return pipe. The return is a 2½-in. galvanized-iron pipe buried 6 ft. below the ground, no expansion joint and no insulation being employed.

When this heating system is first started in the fall there is excessive

FIG. 7. OPERATING FORCE

FIG. 8. SHOWING METHOD OF BENDING PIPE

are each direct-connected to the switchboard.

The switchboard (Fig. 5) consists of two marble panels supported on an iron-pipe frame. One panel is used for the generators and the other for the storage battery. The feed-line fuses and the control switches are placed on a special panel, which is attached to the wall in back of the switchboard. The generator panel is of standard construction having a voltmeter with a three-way switch, an ammeter for each generator, a regulating resistance for each field, a wattmeter to register the entire output of the plant, a circuit-breaker for each generator, and fuses for protecting the armature. It is considered better to rely on fuses than on automatic devices as the labor is unskilled and the writer has caught the engineers tying the starting lever of a motor in the operating position rather than repair the magnet so that it would hold the lever.

HEATING SYSTEM

The main building of the university is about 200 ft. distant from the power house and is heated by both live and exhaust steam, the live steam being supplied to the surge tank through a reducing valve.

The low-pressure steam flows through a 3½-in. pipe from the surge tank to the building, this pipe being in a trench placed from 2 to 4 ft. underground. The trench is lined with ordinary brick laid in lime mortar, and a large brick slab is used to cover the trench before the earth is thrown over it. The pipe is supported every 10 ft. on a double-decked cast-iron roller support, the support be-

As a 90-deg. bend was necessary 200 ft. from the power house, the expansion joint was placed at that point, the pipe being anchored at the power-house end. Inside the building the pipe is drained by a trap and then rises nearly to the

condensation, but after operation for 24 hours there is not more than 1 lb. drop in pressure between the surge tank and the heating coils. During the winter, when snow is on the ground, it does not melt over the pipe trench. The win-

Power Plant—Pei-Yang University—Tientsin

Daily Log *Date* _____

Time	SWITCH BOARD				BOILER AND ENGINE					STORAGE BATTERY				
										Charging		Discharging		
	Volts	Kilowatt hours	Amperes Dynamo No. 1	Amperes Dynamo No. 2	Boiler Pressure lbs. per sq. in.	Exhaust Pressure lbs. per sq. in.	Steam Pressure at engine lbs. per sq. in.	Water meter cu. ft.	Temperature of feed water °	Volts	Amperes	Volts	Amperes	Kilowatt hours
Noon.														
12.30														
1.00														
1.30														
2.00														
22.30														
23.00														
24.00														

Kilowatt hours used | Water Meter cu. ft. | Kilowatt hours from storage battery

Weight of coal: Lighting / Heating / Total

Weight of ashes

PROFESSORS' HOUSES METERS

(1) (A. B. Morrill)
(2) (J. A. Crane)
(3) (E. A. Sperry)
(4) (I. L. Sharfman)
(5) (R. V. A. Mills)
(6) (W. G. Bateman)
(7) (R. T. Evans)
(8) (W. H. Adams)

Break downs

New lamps supplied

New carbons in arc lamps

Clock Room

Class Rooms

Specific Gravity of solution after charging

Specific gravity of cells 8 A M

Sp. Gr.	Number of cell	Eng. oil Cyl. oil Remarks
1.2000		
1.1975		
1.1950		
1.1925		
1.1900		
1.1875		
1.1850		
1.1825		
1.1800		
1.1775		

FIG. 9. DAILY LOG SHEET

basement ceiling. It then continues along the basement for another 200 ft. with an expansion joint at the further end. In the basement the pipe is insulated with asbestos pipe covering. Each heating coil is supplied with one gate valve

ters in north China are very dry so that no trouble is experienced, because the dry earth acts as an insulator.

Small stoves are used in the pump houses in winter to prevent freezing. The pressure tank has never frozen and is

not protected in any way where exposed above the ground. The lowest temperature is a few degrees below zero and the average winter temperature is about 15 to 20 deg.

Operation

An interesting part of the power house is the space occupied by the engineering force as living rooms. There are six men on the force. The chief engineer lives in the room marked "engineer's room," in the plan, his furniture consisting of a table and a bed, the latter made of two sawhorses with planks laid across them. All the other men are supposed to sleep in the firemen's room. Generally, however, these men move their beds to the top of the boilers in winter and sleep outside in summer. Their food, consisting mainly of rice, is brought to them three times a day from the university kitchen by a coolie. Each man pays the university cook about $1.50 a month for his food.

The operating force is shown in Fig. 7. Beginning on the left, the first man is a coolie whose duty it is to clean and look after the regulating valves on the water system; next is a fireman, then the second assistant engineer; the fourth is the chief engineer, the fifth the other fireman and on the end is the first assistant engineer.

The chief receives $14.70 a month; the first assistant $8.40, the second assistant $3.80 and the firemen $5.10 and $4.20 respectively.

Careful records have been kept ever since the plant was started. All the coal is weighed and the water and wattmeters are read every day. Fig. 9 shows the daily log that is filled in by the chief engineer.

The cost per kilowatt-hour is high as the plant does not operate more than six hours a day, except when used for heating. When the generators are not in operation, current is supplied from the storage battery. Street lamps on the university grounds are lighted all night, but the light is cut off from student dormitories and university buildings at 11 p.m. This is necessary as the Chinese at the university will use a light all night even when sleeping. The engines are used on alternate nights and the boilers are alternated every two months.

At present, most of the apparatus is in duplicate as only half is used at a time. There are three reasons for this: first, the present load is smaller than was estimated due to tantalum lamps being used instead of carbon; second, a partial duplication was allowed to prevent a complete shutdown of the plant, and, third, provision was allowed for the future expansion of the university.

Without allowing for interest and depreciation but including all repairs, lamp renewals and new carbons in the arc lamps, the cost has varied from 4½ to 7½c. per kilowatt-hour. This is high, but the cost of supplies is excessive and the number of hours of operation is small.

Fig. 8 shows two of the men bending a 4-in. pipe for the water system, it being necessary to put a double bend for an offset of 4 in.

The water system cost $8160; the power house and the chimney $3336; the boiler-room apparatus and the heating plant, $7800; and the engines and electrical apparatus, $4165.

The Unit of Heat

In response to our inquiry as to whether the heat unit had ever been legally defined or a standard unit adopted in the United States, Director S. W. Stratton, of the U. S. Bureau of Standards, writes as follows:

The British thermal unit has never been legally defined, nor have any international congresses, in their various steps toward properly defined and definitely related units of measurement, given any consideration whatever to this one.

Wherever it has been employed as a unit of heat it has been understood to mean simply the quantity of heat required to raise the temperature of 1 lb. of water through 1 deg. F., leaving the particular degree to be specified, if necessary, by the writer publishing the data in terms of such unit. The total variation of the specific heat of water between the freezing and boiling points being only about 1 per cent., and the difference in the heat units most likely to be used being but a small fraction of this, as set forth later, it must be assumed that when the term B.t.u. is employed without specifying any temperature at the same time, the data given are without significance in the figure where a consideration of this point would make an appreciable difference.

In very few, if any, cases where the B.t.u. has been employed in publishing data, has the work been of a nature to warrant the refinement of specifying the temperature. For the sake of comparison with the important work along the same lines in Germany, France and all other countries using the international metric system, aside from the advantage of the greater convenience in employing it, it is becoming more and more common in America to state heat measurements in terms of the units of this system, just as electrical measurements have from the very first been so stated.

The scientific unit of heat is called the calorie and is defined as "the quantity of heat required to raise the temperature of one gram of water through one degree Centigrade," the mean temperature of 15 deg. C. (= 59 deg. F.) being understood whenever no other is clearly specified. From time to time other units have been proposed, but they have not attained wide acceptance and when employed, they are clearly indicated.

From probably the best work so far done upon the variation, with temperature, of the specific heat of water, the following values are quoted:*

In terms of the 15-deg. calorie as a unit for comparison, the 4-deg. calorie = 1.004 15-deg. calories. 4 deg. C. = 39.2 deg. F. (The 4-deg. calorie has been proposed because of the maximum density of water occurring at about this temperature.)

The 15-deg. calorie = 1 15-deg. calorie. 15 deg. C. = 59 deg. F.

The 20-deg. calorie = 0.999 15-deg. calorie. 20 deg. C. = 68 deg. F. (The 20-deg. calorie has been proposed on the ground that a mean temperature about that of the usual laboratory possesses decided advantages.)

The 25-deg. calorie = 0.999 15-deg. calorie. 25 deg. C. = 77 deg. F. (This calorie was proposed as advantageous because from 20 to 30 deg. the extreme variation is but a few parts, probably 2 in 10,000, whence no careful temperature precautions would have to be taken in work involving a direct employment of the unit.)

The mean 0 to 100-deg. calorie = 1.0044. 15-deg. calories. 0 deg. C. = 32 deg. F.; 100 deg. C. = 212 deg. F. (This calorie is independent of the temperature scale, gas, mercurial, resistance, etc., since 0 and 100 deg. are always fundamental points.)

By the definition of the Fahrenheit scale and the internationally fixed Centigrade scale, the ratio of the two degrees is 1.8. The legal definition of the pound in the United States defines it to be a certain fraction of the international kilogram, the decimal value of which fraction to five figures makes 1 lb. equal to 453.59 grams. With the same mean temperature, 1 B.t.u. is therefore 252.0 calories, or

One B.t.u. (59° F.)	= 252.0* 15° calories†
One B.t.u. (62° F.)	= 251.9* 15° calories
One B.t.u. (39° F.)	= 253.0 15° calories
One B.t.u. (32° to 212° F.)	= 253.0 15° calories

The unit of heat officially used in this bureau is the 15-deg. calorie. Upon request, data are sometimes expressed in terms of British thermal units, the mean temperature of the unit employed being stated when the precision of the data requires differentiation. The 60- or the 62-deg. F. B.t.u. (being for all practical purposes identical with the 59-deg. F = 15-deg. C. one) is probably more often used by the bureau than any other.

*Bousfield & Bousfield, Phil. Trans., Royal Society, series A, Vol. 211, page 199, 1911. "The Specific Heat of Water and the Mechanical Equivalent of the Calorie at Temperatures from 0° C. to 80° C.

†These are the small or gram calories.

Comparing Turbo-Pumps, Blowers

By Charles A. Carpenter

By means of reducing to a basis of unit speeds, various types of direct-connected turbo-pumps and blowers may be compared for the purpose of selecting the most economical unit.

Under general operating conditions for low head, the speed corresponding to the best efficiency on the driven unit is far below the most economical speed of the turbine. Consequently, the introduction of a higher-speed pump or blower is a progressive step of interest to the engineering profession.

How far an increase of speed may be carried without passing safe rotative velocities can be judged by noting, for example, that for circulating service requiring 20,000 to 30,000 gal. per minute against a 20- to 50-ft. head, 600 to 1000 r.p.m. is considered a high speed. The horsepower here is far below that of turbo-alternator sizes, easily running at 3600 r.p.m. Turbine-driven boiler feed pumps of large horsepower often operate at speeds of over 3000 r.p.m. Thus a very revolutionary advance in low-head pump or blower speeds would be needed to cause alarm from rotative velocities.

The design of centrifugal machinery, including water turbines, pumps, blowers, etc., is governed by laws quite thoroughly understood by engineers. By means of these relations, a comparison of various types of pumps for turbine drive may be made by reducing all to the condition of unit head and unit water horsepower, and noting the corresponding speed in revolutions per minute.

Briefly, these laws, at constant efficiency within limits for machinery of homologous design, are:

(1) The speed is proportional to the square root of the head.

(2) The power is proportional to the three-halves power of the head.

(3) The power varies as the square of the impeller diameter.

(4) The speed is inversely proportional to the diameter.

Let

N = Speed of the pump;
P = Water horsepower;
D = Diameter of impeller;
h = Head;
h_1 = Unit of head = 1 ft.;
P_u = Unit of power = 1 water horsepower;
N_1 = Speed of impeller at 1 ft. head;
P_1 = Power of impeller at 1 ft. head;
D_u = Diameter of homologous impeller developing a unit water horsepower at 1 ft. head;
K = A factor representing the speed of a similar impeller developing 1 hp. at 1 ft. head.

Stating the foregoing laws algebraically,

$$N_1 : N = 1 : \sqrt{h_1} : 1 : \sqrt{h} \qquad (1)$$

$$P_1 : P = h_1^{\frac{3}{2}} : h^{\frac{3}{2}} \qquad (2)$$

$$P_1 : P_u = D^2 : D_u^2 \qquad (3)$$

$$N_1 : K = D_u : D \qquad (4)$$

Rearranging these expressions,

$$N_1 = N\sqrt{\frac{h_1}{h}} \qquad (1)$$

$$P_1 = P\left(\frac{h_1}{h}\right)^{\frac{3}{2}} \qquad (2)$$

$$D_u = D\sqrt{\frac{P_u}{P_1}} \qquad (3)$$

$$\frac{N_1}{K} = \frac{D_u}{D} \qquad (4)$$

Substituting equations (1), (2) and (3) in equation (4),

$$\frac{N\sqrt{\frac{h_1}{h}}}{K} = \frac{D\sqrt{\frac{P_u}{P\left(\frac{h_1}{h}\right)^{\frac{3}{2}}}}}{D} = \sqrt{\frac{P_u}{P\left(\frac{h_1}{h}\right)^{\frac{3}{2}}}}$$

Simplifying,

$$K = \frac{N \times 1 \sqrt{P} \times h_1^{\frac{5}{4}}}{1\sqrt{P_u} \times h^{\frac{5}{4}}}$$

If $P_u = 1$ hp. and $h_1 = 1$ ft.,

$$K = \frac{N \times 1 \sqrt{P}}{h^{\frac{5}{4}}}$$

or

$$K = \frac{R.p.m. \times 1 \sqrt{\text{water horsepower}}}{Head^{\frac{5}{4}}}$$

Since a water horsepower equals $\frac{Qh}{3960}$ when Q is expressed in gallons per minute,

$$K = \frac{R.p.m. \sqrt{\frac{1}{3960}} \times 1 \sqrt{Q}}{h^{\frac{5}{4}}}$$

Taking the revolutions per minute equal to 100 as a basis (then K at any other speed is directly proportional) with Q equal to 10,000, and converting to a logarithmic equation, the following is obtained:

$$log.\ K' = 2.2011 - \tfrac{3}{4}\ log.\ h$$

(Equation A)

The curves in Figs. 1 and 2 show the relations between the quantity in gallons per minute and K' for various heads in feet of water. These are calculated similarly to equation A.

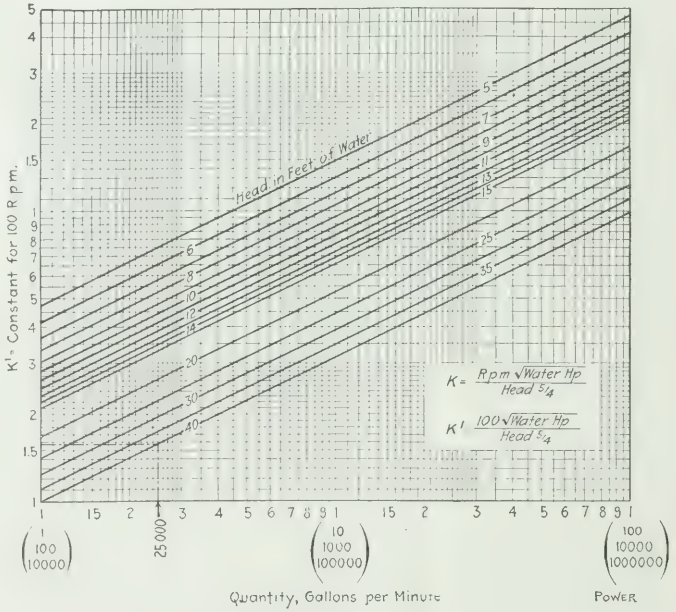


FIG. 1. CHART FOR PUMPS, SHOWING VALUES OF CONSTANT K' FOR HEADS FROM 5 TO 40 FT.

Fig. 3 shows a similar relation between the quantity of air in cubic feet per minute and K' for different heads in inches of water, where

$$K' = \frac{100 \times 1 \sqrt{\text{air horsepower}}}{Head^{\frac{5}{4}}}$$

Suppose an engineer wishes to correctly compare a number of pumps for some specific conditions; for example,

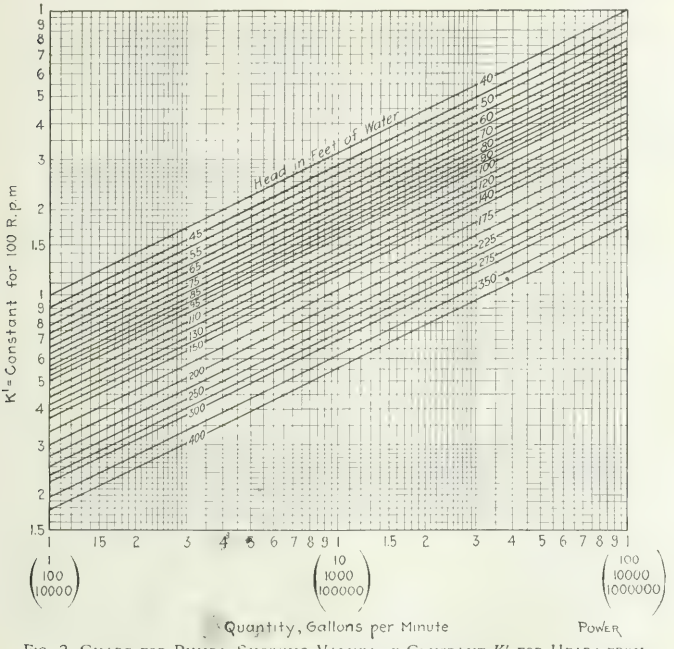


FIG. 2. CHART FOR PUMPS, SHOWING VALUES OF CONSTANT K' FOR HEADS FROM 40 TO 400 FT.

25,000 gal. per minute against a 40-ft. head. From the curves in Fig. 1 it will be found that conditions give a value of $K' = 15.8$.

Now suppose several pumps have been tested and the efficiencies obtained, also that the quantities have been substituted in the foregoing formula for the value of K. Let these be as follows:

Pump	K	Efficiency
A	174	60
B	147	55
C	124	60
D	118	69
E	134	70

Reducing all to 25,000 gal. at a 40-ft. head, it would be right to expect speeds, as follows:

K for pump A = 174

K' at 100 r.p.m. = 15.8

But,

$$K = \frac{R.p.m. \sqrt{water\ horsepower}}{Head^{\frac{5}{4}}}$$

and

$$K' = \frac{100 \sqrt{water\ horsepower}}{Head^{\frac{5}{4}}}$$

Hence

$$\frac{K}{K'} = \frac{R.p.m.}{100}$$

Therefore, the revolutions per minute for the given conditions equal

$$\frac{100 \times K}{K'} = \frac{100 \times 174}{15.8} = 1100$$

Taking data of a well known turbine, at random steam conditions, the water rates corresponding to the speeds are

TABULATION OF RESULTS.

Pump	K	Speed	Pounds of Steam per Brake Horse-power-hour	Efficiency	Pounds of Steam per Water Horse-power-hour
A	174	1100	40.5	60	67.5
B	147	930	45.5	55	82.8
C	124	785	51.5	60	85.8
D	118	745	53.5	69	77.5
E	134	850	49.0	70	70.0

as shown, and with the efficiencies given, the water rates in pounds of steam per water horsepower-hour are calculated as in the last column.

Pump A is thus seen to be best, although it is not evident from a consideration of the pump efficiencies alone.

BLOWERS

The use of the curves for a blower problem will now be shown. Assume that it is desired to obtain 45,000 cu.ft. of air per minute at a pressure corresponding to 5.6 in. These conditions call for a constant K' of 73.2 at 100 r.p.m. From the information given in a catalog and proceeding as in the case of the pump, it is found possible to obtain a constant of $K = 590$. It would then be possible to operate at 807 r.p.m. with an efficiency of 60 per cent., as shown in the following tabulations. For the given conditions, the turbine water rate would vary with the speed, as shown, and it would be known at once that 1 air horse-

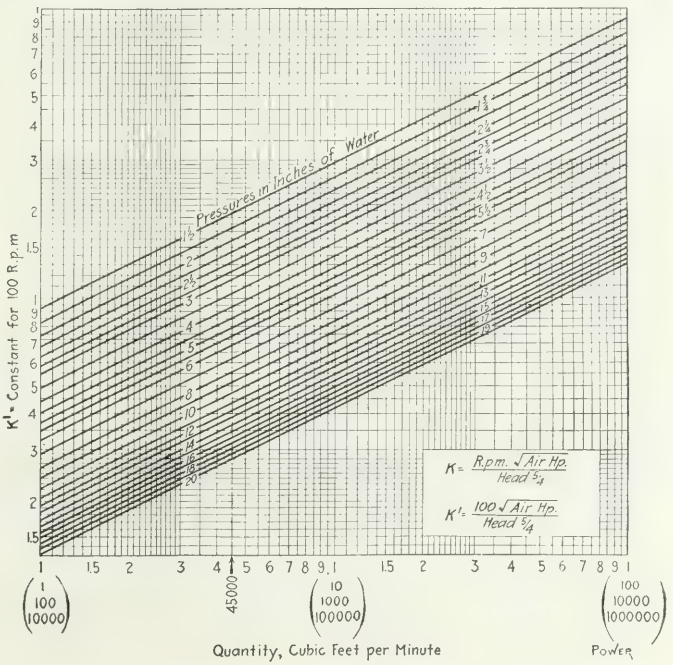

K'= Constant for 100 R.p.m
Pressures in Inches of Water
K= R.p.m. √Air Hp. / Head 5/4
K'= 100 √Air Hp. / Head 5/4
45000
Quantity, Cubic Feet per Minute
Power

FIG. 3. CHART FOR BLOWERS, SHOWING VALUES OF K'

power could be expected for 133.3 lb. of steam per hour.

No.	Speed	Pounds Steam per B.Hp.-Hr.	Pounds Steam per W. Horse-power-hour	Eff. Required	K'	K
1	807	80	133.3	60	73.2	590
2	1000	70	133.3	52.5	73.2	732
3	1200	62	133.3	46.5	73.2	878
4	1500	54	133.3	40.5	73.2	1098

How much the efficiency could be sacrificed for speed to keep as good results is answered by the foregoing comparisons. The engineer would be inclined to investigate blowers of higher speed, and from Fig. 4 it will be seen that it is possible to better the economy shown by the standard blower *A*.

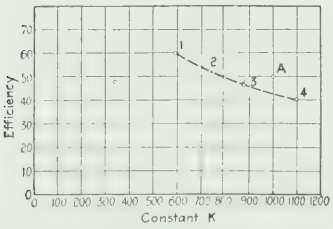


FIG. 4. BLOWER EFFICIENCY CURVE

In conclusion, the writer would urge all engineers buying, selling or operating centrifugal machinery to use such curves as shown in Figs. 1, 2 and 3 for calculating constants for operating conditions, and then to refer to the efficiencies as derived from tests for comparisons. Then, by taking data from one turbine builder, the best pump or blower for the work could be selected, leaving the selection of the turbine as a separate problem. There is no doubt that such investigation would bring to light the great value of larger constants *K*, or unit speeds as they are called, for turbine-driven units where low pressures are required.

The theory of unit speeds for water turbines is given in a paper by Chester W. Larner, entitled "Characteristics of Modern Hydraulic Turbines," and printed in the *Transactions* of the American Society of Civil Engineers, volume 66, page 306.

Peculiar Steam-Engine Design

If one but had the time to hunt them up, many curiosities in engine and boiler designs could be brought to light. The textile mills in small towns are particularly notable in this respect, which is probably because such enterprises were originated by an individual, and that the power equipment has been made to do its work, even though it may be obsolete and uneconomical.

But when these enterprises fall into the hands of large companies, these obsolete designs of power units are discarded and modern equipment is installed. A notable example is shown in the accompanying illustration which pictures an old-time steam engine that was installed at the Dutchess mill of the Garner Print Works, Wappinger Falls, N. Y. At this plant extensive alterations are being made in the power equipment, an electric drive being installed and the old steam installation being discarded as fast as the improvements will permit.

In Fig. 1 is shown one of the engines on its original foundation. The steam valve-gear mechanism is placed above the steam chests, which are on the inside of the cylinder, and each valve-gear and cylinder is equipped with a separate governor.

In Fig. 2 is shown a near view of the valve-gear and the governor. A close examination shows that as the governor balls rotate, in a higher plane than shown, the arm attached to the fly-ball arm will force the governor spindle down, and, through lever connections, move the rod, which extends to either end of the cylinder, in and out, thus actuating a catch-block arm, and regulating the cutoff as the load varies.

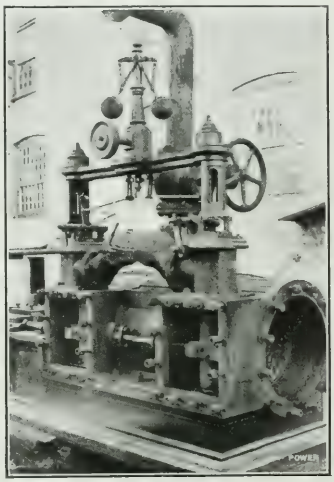


FIG. 2. VIEW OF THE VALVE GEAR

The valve-gear is operated by means of an eccentric and detachable reach rod. As the crank at each end of the cylinder is moved back and forth it engages and becomes disengaged with the catch block on the valve stem, and being under the control of the governor, steam is thus admitted to and cut off from the steam cylinder. The two D-exhaust valves are operated by a single eccentric and valve stem, both valves being attached to the same stem as indicated.

It is unfortunate that the writer was not able to view this interesting engine before it had been demolished, in order that a more comprehensive description of the valve-gear and its operation could have been obtained.

If any of our readers are familiar with this old type of engine it would be interesting to have more detailed information on its design and operation.

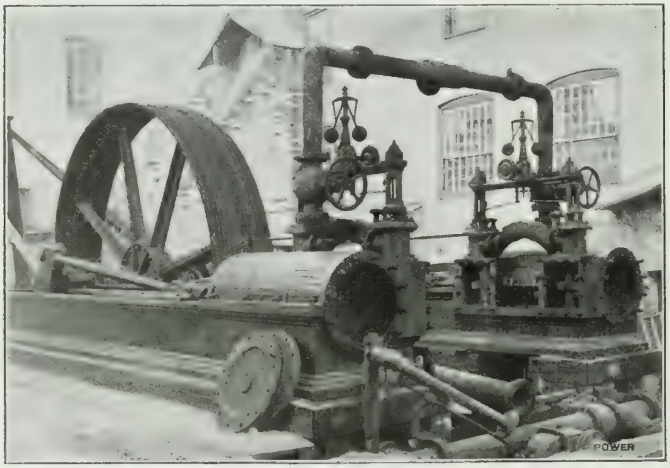


FIG. 1. ODD MAKE OF ENGINE RECENTLY DEMOLISHED

It is the policy of the University of Toronto to compel its mechanical and industrial students to spend at least eight months' actual work in manufactories under workmen's conditions. Training given in university shops, it is contended, falls short of fulfilling the practical requirements when the student enters the field of actual endeavor.

Combined Ash and Coal Storage

By W. O. Rogers

Coal and ash are handled by the same conveyor.

The coal bin consists of two sections, one having a capacity of 1000 tons, the other 250 tons; the large bin holds an emergency supply.

Another bin holds the ashes until a carload has accumulated.

One of the interesting features of the Hazard Manufacturing Co.'s new plant, Wilkes-Barre, Penn., a description of which was published in a recent issue, is the manner in which the coal and ashes are handled.

Coal Bins

Facing the boiler front is a concrete partition, behind which a coal bin has been constructed. This bin is made in two sections; one is for the storage of coal, the other to contain coal that is for immediate use. The upper section, which is located midway of the bin, has a slanting bottom, so that coal will flow by gravity through a chute into a weighing machine that runs on a suspended track in the boiler room.

The main bin is 15 ft. wide, 96 ft. long and is 40 ft. high at the far end and 20x30 ft. on the section of the second bin. This upper bin is supported by six 9-in. iron columns surrounded by cement, making the columns 11 in. square. The coal from the upper or small bin is carried to the coal weigher by means of a coal chute. When the weigher is full it is pushed to whatever boiler requires fuel and the contents dumped on the floor; then it is hand fired to the furnaces. At the bottom of the main storage coal bin in the basement are openings through which the coal can be obtained and supplied to the conveyor which runs under the concrete floor. The coal is thus elevated and dumped into the smaller bin.

This is not the regular practice, but the arrangement has been provided so that in case the coal supply in the smaller bin runs short, or the shipment of coal is delayed, the reserve supply can be drawn from to tide over the emergency.

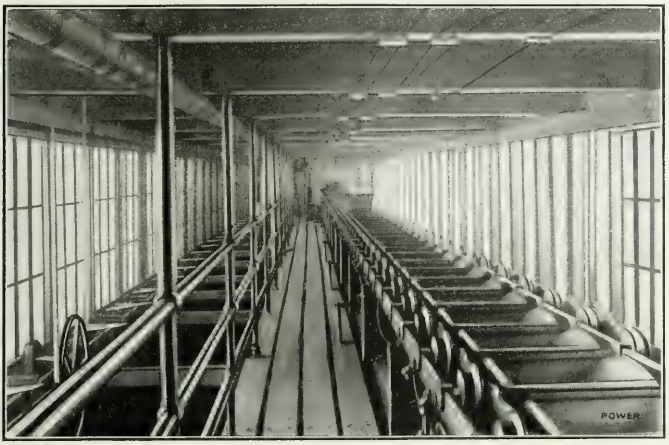


Fig. 1. Conveyor in Monitor over Coal Bin

As the bottom of the coal bin is on a level with the basement floor, the same openings to the conveyor that are used for disposing of the ashes are used in transferring the coal from the large to the small bin.

Conveyor

The conveyor machinery consists of a 10-hp. induction motor operating on a 440-volt circuit, and is located in the monitor over the boiler room. It drives a bucket conveyor consisting of 162 buckets; these are capable of handling 40 tons of coal per hour. It is shown in Fig. 1. The tripping or dumping device is, under ordinary conditions and circumstances, so placed that the buckets will dump their loads into the small or 250-ton coal bin. There are four dumping devices over the 1000-ton storage bin.

At the far end of the coal bin a separate compartment has been built in which the ashes are stored. From this bin the ashes are loaded into wagons on cars and are conveyed away; wagons are mostly used.

The coal is brought to the plant by rail and is unloaded through the bottom of the cars into a concrete hopper built under the track surface, the coal passing through a grating to prevent foreign substances from going in with the coal supply. The bottom of the hopper is fitted with a spout, as shown in Fig. 2, and the coal is allowed to run through this spout to fill the buckets, when it is conveyed to either of the two

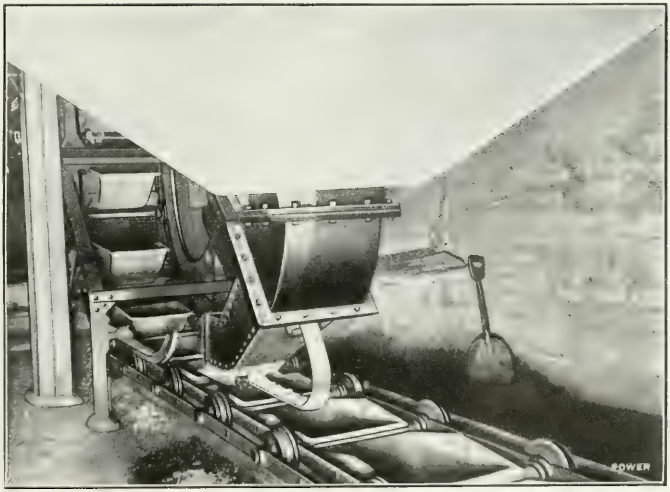


Fig. 2. Hopper through Which Coal Is Unloaded from Coal Car into Conveyor

coal bins. A general view of the coal bins and boiler room is shown in Fig. 4.

Handling the Ash

In Fig. 3 is shown the general arrangement of the basement and the method of handling the ashes from the ashpits of the boilers located on the floor above. Under each ashpit there is a concrete storage receptacle with a slanting bottom, on one side of which is a metal door over the discharge outlet. This ashpit is built so that an ash cart can be run under it as shown. When it is desired to remove the ashes from the ashpit under any particular boiler, the cart is placed under the opening in the bottom and the door is opened, when the ashes run into the cart.

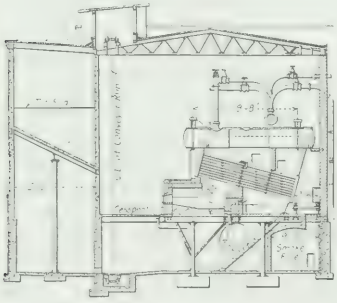


Fig. 4. Elevation of Coal Bins and Boiler Room

The load is then wheeled to the concrete flooring over the conveyor, dumped and the ashes shoveled over the grated openings which are shown over the conveyor that runs under the concrete flooring. These openings are supplied with covers, so that when ashes are not being conveyed the floor presents a smooth surface and any danger of injury from falling into the opening is avoided.

The basement concrete flooring is slanted so that all drippings flow to a sewer and thence to a sump or cesspool. After the ashes have been moved, the floor surface is washed off with a hose, leaving the basement clean and neat.

A feature of the ash conveyor is that the concrete flooring has been built over the conveyor tunnel, so that it overlaps the buckets and there is no chance of the ash and clinker getting into the wheels and bearings of the conveyor. The buckets cannot be overloaded, as a scraper plate has been arranged so that if one bucket gets too much the top surface is scraped off into the next bucket and the load is thus equalized.

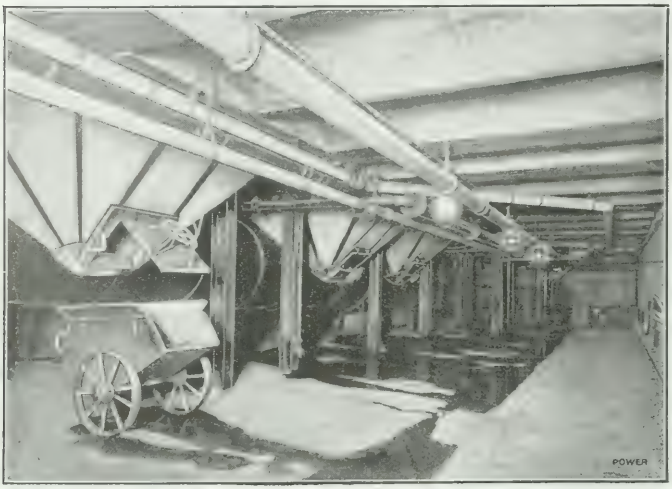


Fig. 3. Ash Hoppers under Boilers, Ash Cart and Concrete Flooring above Conveyor

Repairing Condenser Tubes at Cuban Plant

By F. H. Colvin

One of the large power houses of the Havana Central Ry. is located at Luyano, a few miles distant from Havana. This is a turbine plant of 5000 kw. capacity containing several large surface condensers.

Owing to local conditions, frequent renewals of condenser tubes are necessary, and as the tubes cost $2 each, delivered to Havana, this proved to be a serious item of expense. Consequently the company set about to devise a method of repairing the tubes themselves, by cutting off the damaged ends and brazing a new piece to the good portion of the tube.

For this purpose a gas torch is employed, air pressure being supplied by a foot-operated bellows shown at the bottom of the tank in Fig. 1. The tank acts as a reservoir to maintain the air supply under pressure. The small stovepipe at the back provides a place for the torch when not in actual use for brazing.

The ends of the tubes are scarfed in the same way as when repairing boiler tubes and the piece to be brazed on is clamped as shown, so that the end projects over a bed of fireclay (see Fig. 2). The tube to be repaired is held in position against the new piece while the flame from the torch is applied, keeping the temperature at the brazing point. The usual brazing spelter is used.

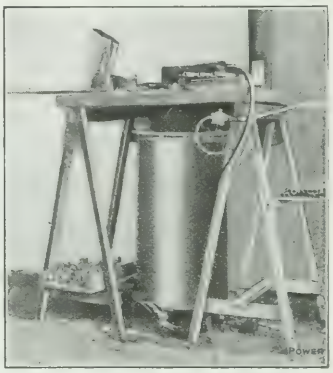


Fig. 1. Brazing Outfit Complete

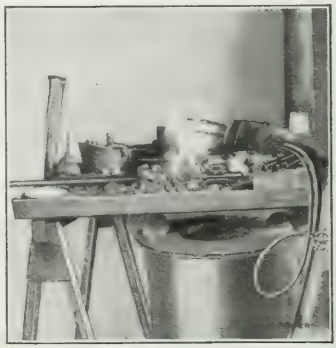


Fig. 2. Tube in Process of Brazing

The operator has become so efficient in the use of this device that instead of the company being compelled to buy new tubes at $2 each, the old ones are repaired at a cost of about $34 per thousand.

The Smoke Abatement Conference

At the International Smoke Abatement Exhibition and Conference, held in London from March 23 to April 4, papers were read by representatives from the world's manufacturing centers, showing what is being done in different localities to overcome the smoke nuisance.

A full line of exhibits was shown, covering smoke consumers, mechanical stokers and various domestic appliances.

The International Smoke Abatement Exhibition and Conference held in London on Mar. 23 to Apr. 4 marked another step in the campaign which is being carried on along educational lines for abolishing the smoke nuisance. Within the past few years a number of similar conferences have been held in the United Kingdom, bearing largely upon local conditions. This conference, however, was international in scope; papers were read by representatives from a number of manufacturing centers in different countries and an opportunity was offered for comparing the various means by which the smoke nuisance is being combated.

The exhibition covered all classes of factory and domestic appliances for minimizing or reducing smoke. Although the exhibits relating to household smoke, due to their popular character, somewhat overshadowed those relating to factory smoke, there was, nevertheless, a creditable exhibit of mechanical stokers, gas producers and smoke-consuming devices. Among the latter were a number of devices for automatically controlling the secondary air supply.

The conference of delegates from local authorities and scientific societies was held on Mar. 26 to 28, and was attended by city councillors, medical officers of health, smoke inspectors and independent smoke reformers. It was stated by the secretary of the Smoke Abatement Society that 71 organizations were represented at the conference, 21 being delegates from the London Borough councils and 9 from foreign municipalities, in addition to which there were official representatives from the governments of Sweden and Holland. A program of 28 papers was arranged for the three days.

The nine papers read on Mar. 26 dealt with the effects of a smoke-polluted atmosphere, upon buildings, paintings, statuary and plants. Details relating to the injury arising from the soot, dust and acid vapors contained in the air, and to the best methods of preserving stone work, metal work and paintings, were given by Sir Arthur Church, H. Redfern, Mr. Ruston, Miss Agar and others. As Walter Reid (representing the Society of Chemical Industry) pointed out in the discussion, competent architects ought to choose their materials with regard to the atmospheric and climatic influences to which they will be exposed, and not indulge in marble and bronze combinations for the center of large cities.

On Mar. 27, sixteen papers relating to the work done in organizing preventive action and to the practical methods of securing the abatement of both domestic and factory smoke were down for reading and discussion. Reports upon the progress of the smoke-abatement movement in Germany, England and America were presented respectively by Herr Ing. Nies, of Hamburg, J. B. C. Kershaw, of Liverpool, and Thomas E. Donnelly, of Chicago. These reports illustrated the widely different methods of attacking the smoke problem in the three leading manufacturing countries. At the afternoon session the subjects of stoking, wasteful power production, and solid smokeless fuels were dealt with.

The "Present Law and Prospective Legislation Relating to Smoke Abatement" engaged the attention of the delegates on Thursday, Mar. 28, when four papers were presented dealing with this side of the subject.

The conferences ended on Thursday evening, Mar. 28, with the passing of a number of resolutions relating to (1) the proposed bill amending the existing laws in relation to smoke; (2) the adoption of a standard method of measuring the atmospheric soot and dust fall and of recording the density of smoke; (3) the education and training of stokers and the granting of certificates for efficiency in their work; (4) the appointment of a royal commission by Parliament for the purpose of inquiring into the whole subject of smoke abatement, and the amendment of the existing laws against smoke; and (5) the coöperation of smoke-abatement societies in other countries with the proposed inquiry of the Pittsburgh University into the economic aspects of smoke abatement.

Abstracts of Selected Papers

"The Growth, Aims and Work of the Hamburg Smoke Abatement Society" was the title of a paper by Herr Nies, who stated that this society was founded in 1902, and is a voluntary association of fuel-users, located in and around the city of Hamburg. Its operations have been extended to cover a large part of the industrial districts in the neighborhood of Hamburg, and its work has been well received even outside of Germany itself.

The parent society has now 328 members who use boilers, besides 102 other members who support its work. The society controls 1345 boilers in the interests of its members, and there are three engineers and five instructors for stokers engaged in this work under the direction of a chief engineer. Boiler plants in Hamburg or its immediate vicinity are inspected three times a year, the object being to instruct stokers, to test the existing apparatus for the control of stoking, and to examine the structural conditions of the plant with regard to economy and smoke abatement.

As a rule, a written report is made for each inspection, covering suggestions for improvements and advising with regard to the purchase of fuel, procuring furnace parts, etc. Furthermore, a special chemical department has been created in Hamburg by the society for the chemical and calorimetrical examination of the fuel used.

Herr Nies then passed on to discuss the factors of most importance in the reduction of smoke, stating that the experience of the Hamburg society had been that it was not lack of temperature, but the inadequate air supply and lack of a proper mixture of this air with the gases given off by the burning fuel, that was the chief cause of factory smoke. It is for this reason, that with hand-fired boilers the society recommends the adoption of automatic devices for regulating the supply of air to meet the varying demands of the furnace.

The author concluded with the following plea for the formation of societies similar to the Hamburg society in other cities and countries:

> It is our endeavor to base the arguments for smoke prevention upon technical grounds. We do not wish to wait for the pressure of public opinion, aroused by a general propaganda for the abolition of smoke, but we wish to gain partisans for our views among technical men themselves, and the recognition on their part that a smoky chimney must now be considered as a symptom of inefficiency and bad management. No employer can desire that his works should be recognized externally as being badly managed. He will, therefore, in his own interests endeavor to remove a defect so plainly visible as the emission of clouds of black smoke, the more so when he is convinced that there is a remedy at hand which is in accordance with his economic interests. We look forward to a solution of the smoke question with the aid and coöperation of factory owners and not in opposition to their wishes or desires.

Smoke Abatement in Germany

Dr. Kobbert, manager of the gas works at Königsberg, Germany, stated that the first real progress in the campaign against black smoke in Germany

dates from the promulgation of the Prussian State regulations on the subject. These were copied by all the other states of the German Empire. The next step in advance was the interest aroused by Dr. Ascher's investigation upon the relation between the purity of the air supply and the diseases of the throat and lungs, carried out in 1905 in Königsberg. This investigation led to a claim that the purity of the air-supply ought to be of equal importance to that of water supply and drainage, and to the founding in 1906 in Königsberg, of a society for smoke prevention which publishes annual reports upon the subject.

The following principles have been generally recognized in Germany as governing all attempts to minimize smoke: Chemical and calorific examination of the fuel ought to precede its selection for any purpose. The type of furnace and method of firing should then be chosen, with an eye to the cheapest and most easily transported coal available in the locality of the works where it is to be used. Having selected a type of furnace and fuel suited to one another, the question of the best method of supplying and regulating the primary and secondary air must be worked out by actual trials. For this purpose CO_2 testing apparatus must be installed, and if possible a continuous recording apparatus also, in order to indicate the smoke emission.

The importance of employing a thoroughly competent fireman was next touched upon, and the author stated that automatic apparatus for regulating the secondary supply must be installed when such a man is not available.

The difficulty of avoiding smoke with household fires and with bakers' ovens was next dealt with, and it was stated that these together cause the larger portion of the smoke in German towns and cities. It has been recognized in Germany, however, that there comes a point when the attempt to obtain the smokeless combustion of bituminous fuel becomes unprofitable, and that the only real solution of the bituminous smoke problem is to forbid its use for manufacturing or domestic purposes. This opinion favors the substitution of anthracite, coke or oil for bituminous fuel; or if the latter must be employed, the combustion of the volatile constituents of the coal, separate from the solid. The slow-combustion stove, burning coke, or the earthenware stove, burning coal, are both smokeless methods of heating houses. Hot-water heating is also being widely employed in Germany for dwelling-rooms and flats. The use of oil for heating purposes is extending.

Recent Progress against Black Smoke in the United Kingdom

This was the subject of a paper by J. B. C. Kershaw, who contended that the most direct proof that the soot and dirt suspended in London's atmosphere were diminishing rather than increasing in amount, was to be found in the figures relating to the duration of fog in London, published in the 1910 report of the Coal Smoke Abatement Society. These figures, representing the annual averages for three successive periods of nine years each, are reproduced below.

Period	Average per year. Days with fog
1883-4 to 1891-2	29.9
1892-3 to 1900-1	20.7
1901-2 to 1909-10	10.6

The steadily increasing purity of London's atmosphere indicated by these figures was confirmed by more recent figures obtained from Dr. Norman Shaw for the period 1902 to 1911. These showed a gain of 84 hours of sunlight per annum, and a reduction of 10 days for fog, when the averages for the two corresponding five-year periods were compared.

The author stated that the increased attention which was now being devoted by public authorities and voluntary societies in the United Kingdom to the subject of smoke abatement was most strikingly reflected in the extension of educational work, which was regarded by many as the most useful and hopeful line of attack upon the black-smoke evil. The classes for stokers, promoted by the Coal Smoke Abatement Society and started at the London Borough Polytechnic Institute in the winter of 1906-1907, had been followed by the inauguration of similar lectures in Glasgow, Liverpool, Manchester and other manufacturing centers.

To show how rapidly gas is displacing solid fuel for cooking and heating purposes, Mr. Kershaw cited figures from the *Gas World Year Book*, showing the increase in the total number of gas cookers in use in the United Kingdom during the period 1902-1912, to be 998,878 for 1902 and 2,921,299 for 1912, an increase of 1,922,421 in the 10 years. This, of course, does not include gas fires. Also the steel manufacturers in Sheffield have appointed a committee to investigate the possibilities of gas and electric furnaces, as substitutes for the smoke-producing reheating furnaces of that city.

In conclusion, the author drew attention to the fact that, although bituminous coal can be utilized now for all industrial purposes without the production of any smoke, by aid of well known appliances and methods of work, it by no means follows that changes will not be introduced into the methods of employing this type of fuel for heating and steam-raising purposes in the near future. He was of the opinion that the gas engine and oil engine will gradually supplant the steam engine as a prime mover, and with this change the burning of bituminous coal under steam boilers will give place to its utilization in the gas-producing plant. Gas-fired boilers and furnaces will also take the place of those now heated by solid fuel, and in this new development Prof. Bone's system of surface combustion will play a leading rôle.

Smoke Abatement in America

Thomas E. Donnelly, chairman of the smoke-abatement commission of Chicago, stated that the active movement to improve the atmosphere of Chicago, as regards smoke contamination, dates from 1907, when the commission upon smoke abatement was appointed, with the author as chairman. The commission was composed of business men, and powers were obtained to inspect all plans of new power and heating installations, together with plans for the alteration of existing plants, and to reject them if it was considered likely that a smoke nuisance would be caused. The commission was also authorized to inspect and report upon all steam-raising and heating plants, and to make recommendations for their better working, if this appeared necessary.

When an owner proved obstinate about carrying out the suggested alterations, fines could be imposed, but as a rule it was not found necessary to resort to this.

The official staff of the commission consists of 22 engineers and clerks, with a numerous body of smoke inspectors. It is claimed that the smoke nuisance in Chicago has been reduced one-third, and in some individual cases by 75 per cent., as the result of the work of this commission—and the message from Chicago to the International Smoke Abatement Conference was that the smoke evil can be best attacked and abolished by administrative methods.

Another paper upon the smoke problem in America was read by J. A. Willard, of Boston. The author's remarks were confined specially to that region in which soft bituminous fuel is mined and sold, at the very low rate of about $2 per ton. From the eastern slope of the Rocky Mountains to the western slope of the Alleghany Mountains, railroads and all industries requiring power are forced to use bituminous coal. This coal is for the most part low grade, cheap and smoky.

The smoke conditions in all this region are atrocious. In the great manufacturing cities, such as Pittsburg, Chicago, St. Louis and Cleveland, the injury to health and property has been so great as to provide public inquiry into the causes of smoke, and determination on the part of the authorities, aided by public opinion, to reduce and finally end the nuisance.

In Boston there has been a constant fight for the prevention of smoke wherein the smoke producers have, up to 1910,

had all the advantage. In 1901, the Massachusetts legislature passed a law forbidding smoke from any source, but exempting locomotives. In 1902, this law was amended to exempt brick-kilns in addition to locomotives. In 1905 it was further amended by exempting all public-service corporations and wood-burning plants. In 1908 pottery-kilns were added to the exemptions. It will thus be seen that all the smoke-producing plants were exempt by law, the public being left unprotected and entirely at the mercy of the offenders.

The author then gives the history of the repeated attempts of the citizens of Boston to obtain some amendment of the law. Having failed in these attempts to obtain legislative action, the citizens' committee proceeded to gather evidence of the losses resulting both to the manufacturers and the community from the emission of black smoke, and of the practical methods by which these losses could be minimized. The sequel is best told in Mr. Willard's own words:

> It was definitely decided that so long as bituminous coal was used as fuel, the only relief from the smoke nuisance was in the education of the fireman, and that the management of a fire was as much a science as any other problem of chemistry. Armed with these facts, every smoke-producing industry was interviewed in the friendliest manner; the facts were exhibited, and today Boston can boast of as little smoke annoyance as any city of its size in America.

"Smoke Abatement in Pittsburgh" was discussed by Dr. R. C. Benner, of the Pittsburgh University, who began by stating that it is strange when one stops to consider the breadth of interest and importance of this problem, together with the fact that so many thousands have worked on its various phases and that so much has been written on the subject, that no coördinated effort of one group of men has been made to undertake a scientific study of the problem as a whole. This is the aim at the University of Pittsburgh. The author then described the various branches of investigation that are being pursued by the small commission of scientists who are undertaking the work. These include inquiries into the increased cost of living and the losses to manufacturers due to smoke, the relation of smoke to health, the effects of smoke upon plant life, the effects of smoke upon buildings, statuary and paintings, and the influence of smoke upon the meteorological data relating to sunshine and fog.

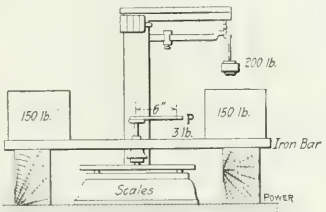
From this brief outline it will be seen that, while the investigation will be of great service to this locality under any conditions, still, if the coöperation of people in other parts of the world, likewise affected by this nuisance, can be secured, comparative results can be obtained which will enlarge the sphere of usefulness, not only to the immediate benefit of Pittsburg, but as well to that of the world at large.

Abuse of Valves

By C. D. Eldredge

In our power-plant work we get together occasionally and discuss features of practical operation. During one of these engine-room conferences a fireman told of a man who had very powerful hands; he took particular delight in closing ordinary globe valves so tight that the stem would be twisted off in trying to open them, if he did not accomplish the same thing in closing the valve.

This incident set me to thinking about the power exerted by the screw and the pressure put upon the valve seat in ordinary practice. A simple experiment, which the sketch will make plain to the reader, was then performed. The stem and bonnet were taken out of a ¾-in. globe valve and fitted into a hole in an iron bar, which was placed over an ordinary platform scales as shown. Running the valve stem down till it touched the platform, a lever was attached to the handwheel and with a spring balance a pull P of 3 lb. on a 6-in. radius was applied. This proved just sufficient to balance the 200-lb. weight on the scales, the screw having a pitch of $\frac{1}{10}$ in. Varying conditions make a wide difference as to the efficiency of the screw, and by actual



Measuring Force Applied to Handwheel of Valve

experiment in our case this efficiency was found to be unusually low. The following formula was used to determine the force exerted at the wheel:

$$W = \frac{2\pi r F}{P}$$

in which

F = Force applied in pounds;
W = Weight or pressure resulting;
P = Pitch of screw;
r = Radius on which force acts.

Substituting the numerical values in this formula gives

$$W = \frac{2 \times 3.1416 \times 6 \times 3}{\frac{1}{10}} = 1244 \text{ lb.}$$

$$\frac{200}{1244} = 0.16$$

or 16 per cent. efficiency of screw. A pressure of 200 lb. is surely enough to close a ¾-in. valve under ordinary conditions.

Taking the above example as a basis of calculation, it may be interesting to work out one or two more problems. The man who grips a ¾-in. globe valve and screws it down hard, applies the force on a radius of about 12 in., the length of the fore-arm, and suppose the force applied is 20 lb.; then the formula will give the following result:

$$W = \frac{2 \times 3.1416 \times 12 \times 20}{\frac{1}{10}} \times 0.16 =$$

$$2654 \text{ lb.}$$

This would seem to be an excessive pressure to apply to the seat of a ¾-in. valve.

A 2-in. globe valve with a screw pitch of $\frac{1}{7}$ in. will next be considered. On the supposition that a man would grasp the handwheel with both hands and exert a pull of 50 lb. on a 12-in. radius, the problem works out thus:

$$W = \frac{2 \cdot 3.1416 \cdot 12 \cdot 50}{\frac{1}{7}} \times 0.16 =$$

$$4222 \text{ lb.}$$

This may be enough to spring a valve body out of shape. Then the only remedy is to regrind the valve.

A short time ago I saw a boiler-room attendant take a 36-in. iron bar, insert it into the handwheel of an 8-in. boiler stop valve to screw it down "tight" so it would not leak steam. He must have pulled at least 200 lb. on that bar, for he was a strong fellow. Here is what he was doing to the valve, which had a screw pitch of ¼ in.:

$$W = \frac{2 \cdot 3.1416 \cdot 36 \cdot 200}{\frac{1}{4}} \times 0.25 =$$

$$45,239 \text{ lb.}$$

and this was not the total pressure on the valve seat. The disk had an area of about 50 sq.in., with 135 lb. per square inch steam pressure upon it as well, which made 6750 lb. more, or a total of 51,989 lb. Dividing by 50 would give a pressure of a little over 1000 lb. per square inch. It may be noticed that in this problem an efficiency of 25 per cent. was used, and for this case the efficiency taken is considered a conservative estimate.

The condition of the screw and its lubrication will influence the results obtained in actual practice, but these three problems will give a general idea of the treatment forced upon thousands of valves every day in the year, and yet the valves themselves are blamed because they do not hold steam or water.

If a valve does not close tight with reasonable pressure, there is no occasion for trying one's strength upon it. Such treatment is apt to ruin the valve. A careful examination will generally show the trouble and a way to remedy it, namely, grinding in or reseating.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Small Direct-current Turbine-Generators

The accompanying illustrations indicate the practice of the Westinghouse companies in the construction of turbine-driven direct-current dynamos of 10 to 300 kw. rating. The steam end is a single-wheel impulse turbine through the blades of which the steam is passed two or more times before reaching the exhaust outlet. The dynamo is a multipolar machine with commutating poles and embodying special armature and commutator construction.

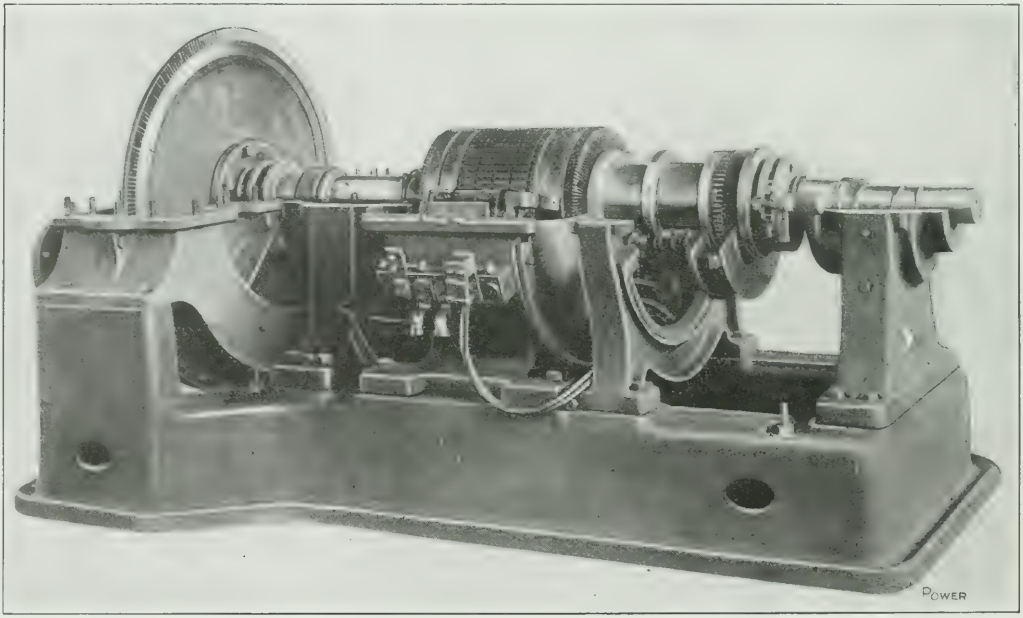


FIG. 1. DIRECT-CURRENT TURBINE-GENERATOR UNIT OF 100 KW.

Fig. 1 shows a 100-kw. unit with the top half of the turbine casing and dynamo field magnet removed. The turbine runner overhangs one of the main bearings in this and smaller sizes, and also in the 200- and 300-kw. sizes when the turbine runs noncondensing. The wheel and blading are of the usual Westinghouse type, and embody no special features.

The dynamo field magnet is built with a split cast-iron yoke ring to the inner circle of which are bolted laminated main poles and solid steel commutating poles. When the main poles are compound-wound, the series winding encircles the shunt winding as shown in Fig. 2. This construction is so clearly shown as to render description unnecessary. Fig. 3 shows one of the commutating poles and its coil.

The armature disks are mounted directly on the shaft, but ventilating openings are stamped in the disks next to the shaft hole. These coöperate with radial ventilating ducts between disks to promote air circulation and thereby the dissipation of heat. The armature disks are clamped between bronze end-plates which are cast each with an axial flange or short barrel to support the projecting portions of the armature winding at each end of the core. This barrel or flange is heavily insulated and the coil projections are bound tightly down on it by means of steel wire.

After the coils are all in place, all openings between the wires at both ends are packed full of a fibrous material soaked in insulating compound. The projecting portions of the coils are then covered with tape, to give a mechanically smooth finish.

The high speed incidental to turbine drive makes it imperative to take special precautions for maintaining the structural integrity of the commutator. Reference to Fig. 1 will show that three rings of approximately square cross-section encircle the commutator barrel, one at each end and one around the center. These are of steel, shrunk on over mica strips, the latter being necessary to prevent short-circuiting the commutator bars. In larger sizes four rings are provided.

At the extreme outer end of the commutator, beyond the shrink ring, may be seen a series of radial vanes resembling fan blades; these are heat-dissipating blades of copper, set into the ends of the commutator bars. The tips of the blades are cooled by their motion through air, and heat therefore flows to them from the commutator bars and is thrown off. Shields are provided which protect attendants from contact with the blades, but these are not closed in against air circulation.

The commutator is built up of hard-drawn copper bars, as usual, with the mica between bars cut down slightly below the surface of the copper. The lugs

or connectors between the commutator bars and the winding are of soft copper having greater current-carrying capacity than the bars. "Le Carbone" graphite brushes are used.

The unit here illustrated was built for supplying a three-wire system balanced by an external autotransformer. For

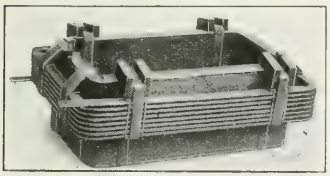


FIG. 2. MAIN MAGNET COILS

connecting the latter to the armature winding, slip rings and brushes are provided, which may be seen next to the inner end of the journal housing at the commutator end, in Fig. 1.

The machine here illustrated runs at

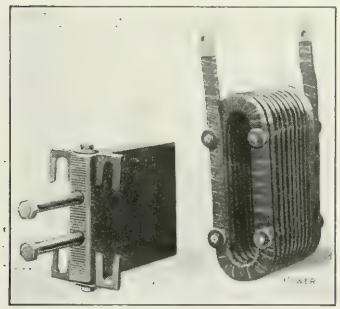


FIG. 3. INTERPOLE AND COIL

2400 r.p.m. The diameter of the turbine runner is 3 ft. 4½ in.; that of the armature is 16 in., and the commutator barrel is 8½ in. in diameter. From these dimensions, the peripheral velocities figure out at 25,450 ft. per minute for the runner, 10,000 ft. for the armature and 5340 ft. for the commutator.

Mr. Insull on Concentrated Power Generation

In an address delivered before the American Institute of Electrical Engineers, on Apr. 5, Samuel Insull, president of the Chicago Edison Co., expressed the opinion that great economies might be effected if railways of all classes would purchase their power from central lighting and power stations instead of building and operating their own power houses.

The amount of energy required to operate the terminal and suburban systems of all the trunk lines centering in or near New York City, Mr. Insull stated, is less than the aggregate energy required to operate the isolated electric-lighting plants in the same territory. It is not a serious proposition, he said; that load is of less consequence to the properly operated electricity-supply company than the isolated-plant business was to the electric light and power companies through the country 20 years ago, or even 10 years ago.

The problem of the relation of the central station to the generation and primary distribution of energy, so far as the steam railroads are concerned, is a question of economics. It cannot properly be considered without taking into account the entire question of generation and primary distribution for any given center of population. If you consider steam-railroad electrification by itself, the amount of energy required seems to be very great indeed. If you consider it merely as an incident of the supply of energy required by a community for all kinds of purposes, it is found to be simply an incident.

The concentration of the production of energy for all purposes required in a given area of population would result in such a saving in capital, and such a saving in operating expenses, as to sufficiently provide for the generating capacity and primary transmission systems necessary to electrify the terminal systems and suburban service of all the trunk lines centering in and around any large center of population, particularly New York, and yield very large profits to the engineers and financiers having the courage to handle so great a problem.

The percentage of saving, he said, is comparatively small. On a percentage basis, the possible saving in Greater New York, including that part of the Jersey shore that would naturally be associated with New York, is comparatively small and somewhat disappointing, owing to peculiar local conditions, but it would amount to a return on such a vast sum of money that he could not see how it was possible, whatever might be the jealousies of management and the individual interests of the financial people operating the various properties, that either the engineers or the financiers could neglect the subject.

Mr. Insull then presented a large chart showing the aggregate load curve of the New York Edison Co., the Public Service Corporation of New Jersey, the Interborough Rapid Transit Co. and the station of the Hudson tunnel system. This chart showed a maximum load of 678,000 kw., and Mr. Insull stated that if this load were all supplied from one system the "diversity" factor would reduce it to 630,000 kw. and the load factor would be 40 per cent. instead of 36.9 per cent., which it averaged for the several independently operated systems during the winter just ended.

[Mr. Insull's diversity factor was apparently the percentage of the combined maximum by which that maximum is exceeded by the present aggregate of individual maximums.]

He then presented charts showing the load curves, separately, of the New York Edison Co., the electric railway systems and the Brooklyn Edison Co. and showed that the diversity of maximum load periods was such that combination supply would reduce the maximum load by about 15 per cent., the diversity factor being 17½ per cent.

Charts showing various other load curves were also shown and analyzed in support of the argument.

Reverting to the situation in New York, he said that if the power-generating systems of the whole city and its environs were consolidated into one; the reduction in investment would amount to $18,000,000 or $20,000,000 and the operating expenses would be reduced about $1,000,000 a year.

LETTERS

Commutator Lubrication

Having used several different preparations on commutators for lubricating purposes and not finding anything that gave good service excepting a common light grade of machine oil applied to commutators with a piece of cloth, I would like to hear what other readers of POWER have found that gave good results.

I have used machine oil on the commutator of a direct-current generator for some time and it seems to give very good service. The brushes do not cause any trouble from sparking, neither do they show excessive wear. The commutator also keeps very smooth.

I take the brushes off about once a month and clean them up; then, while the machine is running slowly, I polish the commutator with ordinary sandpaper. This keeps both brushes and commutator in good condition.

Has anyone any suggestions?

G. ALTON BARRICK.

Kenmare, N. D.

High Mica

Upon visiting a friend recently I found him and two assistants working over a direct-current dynamo which he said had been out of commission for five days—would not pick up its field magnetism at all. He said he had tested every connection and circuit on the machine and found them all right.

A little investigation convinced me that his trouble was due to high mica between the commutator bars, and after considerable argument I persuaded him to cut it down slightly below the surface of the bars with a narrow chisel. When this was done and the commutator smoothed up with sandpaper, the machine picked up promptly. It has been running smoothly ever since.

J. G. KOPPEL.

Montreal, Can.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

A Few Problems in Bituminous Suction Producer Plants

By Frank Fielden

The specifications issued by builders of suction producers show that in most cases guarantees as to fuel consumption and quality of gas are based on the use of anthracite coal of a certain size. So widespread has become the use of this class of fuel that the cost has naturally increased to such an extent as to preclude the possibility of obtaining the high plant economy of eight or nine years ago. The limited areas in which suitable anthracite can be profitably mined and sold, and the widespread distribution of bituminous coal seams throughout the world, are further strong incentives to the engineer to construct a suitable suction-type generator for the satisfactory gasification of native coals which have hitherto been useless for the purpose.

It is not too much to expect that eventually even such coal as is found to be unprofitable and unsuitable for steam raising in boilers, on account of the high percentage of ash contained, will be satisfactorily and profitably gasified in this class of gas producer. At present, makers of pressure-type gas producers of the external tar-extractor class are finding this a profitable field of exploitation, coal containing almost as much as 40 per cent. of ash being successfully and profitably gasified for the driving of gas engines. The value of such a coal for steam-raising purposes is practically nil; hence such a fuel is at present either left unmined or is dumped on to the waste heaps around pit-mouths.

As the volumetric proportion of carbon contained in anthracite coal is in excess of that of any other fuel commercially obtainable, it stands, by virtue of this quality alone, above all other coals for use in suction gas producers. The extremely low percentage of ash and volatile matter of a tarry nature contained in anthracite coal also conduces very materially to its preëminent suitability for the generation of suction gas.

Within the last seven or eight years gas coke has been used for fuel with varying success, and makers have adapted their gas plants where required to suit the different conditions imposed by this fuel. The lower specific gravity of the coke demands a generator of greater cubical capacity, while the increased percentage of ash it contains, amounting in some cases to as much as 20 per cent., as compared with 1 to 5 per cent. in anthracite, necessitates increased facilities for removing clinker and ash. The increased amount of tarry volatile matter given off by the coke requires larger scrubbers and more extensive filtering to insure the gas being clean at the engine valves.

The proportions of ash and tar in gas coke vary considerably. In some districts it may be obtained almost equal to oven coke, and in other districts it approximates bituminous coal with respect to these two qualities. Even from the same gas works the fuel often varies. Owing to insufficient carbonization the coke leaves the gas works in some instances in such a condition as to prevent actual commercial success being obtained in an ordinary anthracite type of suction plant. The writer has seen a deposit of tar, equal in bulk to a walnut, on the inlet valve of a gas engine after a 10-hour run, from gas coke in a plant containing double the amount of scrubbing apparatus necessary for anthracite. It is not surprising then that early attempts at gasifying bituminous coal in a suction plant have failed to reach a commercial standard of success.

In the classification of coals, bituminous coals come between lignites at one end of the scale and anthracite at the other. Various methods of classification have been adopted, but after an extensive system of analysis and investigation of existing methods and results, Seyler states that with coal containing over 84 per cent. of carbon the proportion of the total hydrogen obtained by analysis is the most correct index, and for coals below this percentage of carbon the basis of classification is the percentage of carbon alone.

SEYLER'S CLASSIFICATION

	Hydrogen	Approximate Volatile Matter
Anthracite genus	Up to 4%	Up to 10%
Carbonaceous genus	4 to 4.5%	10 to 16%
Semi-bituminous genus	4.5 to 5%	16 to 24%
Bituminous genus	5 to 5.8%	Over 24%
Per-bituminous genus	5.8% and over	

A more general classification as to volatile matter is as follows:

Anthracite	Up to 8% volatile matter
Semi-anthracite	8 to 10% volatile matter
Dry steam coal (navy)	10 to 14% volatile matter
Semi-bituminous	14 to 20% volatile matter
Bituminous	20 to 40% volatile matter

Gasification of Bituminous Coals

When bituminous coal is fed into an ordinary anthracite suction plant the hydrocarbons are distilled by the heat given off from the incandescent fuel, and these hydrocarbons are drawn through the plant by the suction of the engine, and are deposited in the pipes, cleaning vessels, and on the gas-engine inlet and exhaust valves, and even the inside of the cylinder, resulting in a gradual choking up of the gas-supply pipe with tar and soot and the sticking of the valves and piston of the engine.

It has been thought that by altering the position of the gas outlet of the generator from near the top to near the bottom, the hydrocarbons would be all drawn through the incandescent fire and issue at the outlet as fixed gases, such a type of plant being known as downdraft as distinguished from the ordinary up-draft of the anthracite plant. The problem of successfully gasifying bituminous coal in a suction plant is very closely akin to the much older problem of the smokeless combustion of bituminous coal and the more or less successful results accomplished in the latter problem should be of considerable assistance in the solution of the former, it being clearly understood that there are other difficulties to overcome pertinent to the gas producer itself.

Air and Steam Supply

It is common knowledge that a certain minimum amount of oxygen is necessary for the complete combustion of a certain definite amount of carbon, and in the case of bituminous coal it may be stated in general terms that the combustible constituents require a certain minimum amount of atmospheric air for the complete combustion of the carbon and lighter hydrocarbons given off during distillation and combustion.

In the case of the steam boiler, regular stoking and devices for regulating the amount of air entering the furnace, and also the particular point of air admission, have been effectual in reducing the amount of smoke passing to the chimney. Mechanical stokers have successfully demonstrated the advantage of a regular rate of feed of coal with a view to the combustion of the hydrocarbons as and when formed, and it would seem self-evident that to successfully cope with the hydrocarbons distilled from the bituminous coal in a gas producer, the coal must be fed at a regular rate, preferably mechanically, means being provided to admit and regulate the amount of air necessary for combustion

at such a point as to insure the hydrocarbons distilled from the coal being mixed with the necessary amount of air, and the whole passing together through the hottest zone with a view to the complete carbonization of the raw coal. To this end the air for carbonization should not be mixed with vapor, as this would have a cooling effect, and retard the effectual combustion of the hydrocarbons given off during distillation.

In the earlier experiments with the down-draft suction plants the air for combustion was charged with vapor in exactly the same way as now holds with the anthracite plants; but it was found that, although a sufficient heat was attained for making gas of effective and explosive power, yet the tarry volatiles and soot were deposited in the gas-supply pipes, and eventually found their way to the engine.

Since it is necessary to pass a sufficient amount of vapor through the generator in order to produce good gas without the formation of an excessive amount of clinker, and to prevent the firebrick lining being burnt away, it becomes necessary to divide the functions of the suction bituminous producer into two distinct processes.

First, the coal must be coked, and, second, the coked fuel must be fed with the necessary air and vapor to produce good gas. The latter function is already completed in most suction plants now on the market. The former function is the one to which thought and inventive skill are now being directed, and as in the commercially successful bituminous suction generator, both functions should be combined, together with means for treating satisfactorily widely divergent qualities of coal, both caking and noncaking, containing quantities of ash varying from 5 to 40 per cent., and volatile matter varying from 16 to 40 per cent., some idea of the difficulty of the problems can be formed.

The amount of vacuum at disposal for the separate functions of coking and gas making is regulated by the load on the engine which the producer supplies, and since a definite amount of air charged with vapor is necessary to keep the coked fuel in a suitable condition for gas making proper, it is reasonable to expect that the air supply for coking only should be used to the best advantage. Where large quantities of coal are fed at extended intervals into a gas producer at normal working temperature, the tarry volatiles are quickly given off during distillation, and for the major portion of the interval the fuel is in a more or less fully coked condition.

Assuming a regular constant load on the engine, then the air supply is constant also, and the amount of air drawn into the generator during the coking period is no more, but is actually less, than when the fuel is fully coked, the effect being exactly similar to that produced by irregular stoking in a steam-boiler furnace. Not only is the air supply insufficient to produce complete combustion of the tarry volatiles, but the heat of the generator is considerably reduced during the heating up of the cold mass of coal, and this reduction of heat in the generator is further accentuated by the refrigerating action of the volatilization of the coal during distillation.

The amount of heat absorbed in the volatilization of the coal is considerable, consisting not only of the sensible heat necessary to raise the temperature of the solid carbon, but also the latent heat possessed by the volatiles. In the case of highly bituminous coals this latent heat amounts to about 50 per cent. of the total heat evolved, with the result that the tarry gases pass through the generator unconsumed.

Again, since complete combustion of the volatile gases given off during distillation is only attained through the thorough and complete mixture of these gases with the necessary oxygen of the air induced by the suction of the gas engine, anything which tends to reduce the vacuum available for this air supply will of necessity reduce the possibility of the complete combustion of these volatile gases. In the case of the generator containing fully coked fuel, it can be assumed that the air supply is a maximum; whereas, on the other hand, if a large, or even moderately large, amount of bituminous coal be placed in the generator, the distillation commences immediately, and the volatile gases given off at once tend to reduce the available vacuum, with the result that less oxygen is supplied to the generator at the time when the maximum quantity is most desirable and necessary.

Oxidation of the Fuel Elements

That an intimate diffusion with the necessary amount of oxygen is a necessity in the complete combustion of bituminous fuel has been thoroughly established in furnace practice as confirming the results of the chemical laboratory. To insure this complete diffusion of oxygen with the fixed carbon of the fuel is comparatively simple; it is, however, essential that the hydrocarbons also should be subject to a thorough diffusion with the necessary amount of oxygen in order to complete their combustion. The ignition temperature of the hydrocarbons given off from bituminous coal during distillation ranges from 1100 to 1250 deg. F., when intimately mixed with the necessary amount of oxygen; and since carburetted hydrogen requires twice the volume of air for combustion that is required for the combustion of carbon, means must be provided for supplying a sufficient amount of pure air at the point where the hydrocarbons are evolved. The ignition temperature of carbon being 1240 deg. F., all the hydrocarbons must pass through a zone of such a minimum temperature to effectually prevent the ultimate deposition of soot and tar in the gas pipes and cleaning vessels. The carbon residue remaining—in other words, the fully coked coal—is then in a suitable state for forming the necessary basis for gas production proper, it being understood that the products of primary combustion are passed through this coked fuel.

The importance of a high temperature for primary combustion shows the advisability of preventing at such a point in the evolution of the process the admission of vapor used for gas making proper, while a suitable method of supplying the air in a heated state, as by regeneration, would promote efficiency in the combustion of the hydrocarbons.

To have universal application, a suction bituminous plant should be capable of satisfactorily dealing with both free burning coal and caking coal. It is a natural question to ask what constitutes a caking coal. While there is no simple relation between coking or caking power and chemical composition, it may be stated generally that coals which are either very rich or very poor in hydrogen and oxygen do not melt or cake. The coking property is probably determined by the presence in greater or less amount of certain compounds of carbon, hydrogen and oxygen, which at high temperatures are decomposed into volatile substances and carbon, the latter serving as a cement to bind the particles of the residue together. This caking power is in some cases lost very soon after the exposure to air, on account of the rapid weathering of the coal. The caking power also varies inversely with the percentage of ash contained by the coal, so that a good caking coal has a minimum amount of ash in its composition.

Fuel Characteristics

When caking coal is fed into the top of a generator, whether of the suction or pressure type, it is fused together by the heat, and unless means are provided by agitating or breaking up the caked masses while in the generator, the air for combustion and gas making is not equally consumed through the full area of the fire, resulting in the formation of holes and spaces, through which the air passes at an accelerated rate and produces intense local temperatures, with a corresponding variation in the quality of gas produced.

Although coal loses one-tenth its weight in coking, it increases its volume by one-third. The effect of this is that when fed from the top of the generator arching over of the fuel occurs, particularly in those generators where the inner diameter gradually diminishes, and it has been observed also in generators with parallel walls, the fuel near the bottom

of the generator being almost entirely consumed, and the combustion zone gradually working upward, leaving a hollow space below the arch thus formed. The writer has seen this occur in plants using anthracite coal as fuel. With caking coal, however, the trouble is greatly exaggerated; the fusing of the coal together completes the effect of the natural expansion through heat, and any additional weight from above due to adding more fuel increases the thrust on the sides of the generator exerted by the arch.

In most cases this arching over of the caking coal is prevented by regular hand poking from above; but one or two patents have been granted for mechanically worked pokers, which, projecting into the fuel bed, are given a constant agitating motion. In one American patent means are provided for continuously revolving one section of the generator with a view to prevent the adhesion of the fuel to the interior of the firebrick lining. Other methods of overcoming this caking trouble consist in treating small portions of coal at a time, with a view to supplying each portion with the requisite amount of air, and also affording facilities for the natural expansion and caking before the fuel is fed into the main body of the generator. Thus eventually the coal reaches the main column of fuel in the generator in a fully coked condition. As a satisfactory means of dealing with either the caking property of coal or the successful combustion of the hydrocarbons given off by any bituminous coal, such a method—that is, the separate treatment of each portion of fuel previous to being passed into the main fuel bed—would seem to contain the elements of success.

Tar and Ash Difficulties

It has been suggested by some engineers that the tar from bituminous coal should be extracted from the gas at some point between the generator and the engine, as is accomplished in pressure-type plants by means of extensive condensers, scrubbers, and tar extractors, mechanically operated and otherwise. As the reasons for the existence of the suction plant are its simplicity and the minimum amount of attendance and skilled supervision required, together with the small amount of space occupied, such a solution can be hardly expected to have universal application. A number of plants are, however, working on this system, but it is extremely difficult to find a profitable market for the tar thus extracted, owing to the impurities it contains; and as municipal authorities object very naturally to its being run into the sewers, its disposal is a matter of some moment, particularly in towns and cities. Certainly for ship propulsion such a method would be prohibitive, since the question as to space occupied is a very vital factor in these days of the steam turbine and the more recent Diesel oil engine.

Another trouble which has been experienced by the makers of suction gas plants for anthracite and coke fuel—ash and clinker—is intensified considerably with bituminous coal. Most suction gas plant attendants have experienced annoying stoppages of the engine at one time or another through the opening of doors in the generator during the clinkering and clearing of the ash from the fire in solid-bottom generators, the reason for such stoppages being that while the ash door was opened the vacuum was insufficient to induce the necessary amount of vapor required for the generation of good, rich gas to drive the engine on load. Indeed to such an extent has this possibility of stoppage been prevalent that some makers have advocated and installed twin generators for services demanding extended running periods.

With three or fourfold increase in the amount of ash as obtains in bituminous coal, then, it becomes absolutely essential that means shall be provided for removing such ash and clinker without causing an undue effect on the engine. The composition of the ash as it exists in the raw coal varies considerably, and its behavior inside the generator is no less variable, depending largely on the temperature to which it is subject.

If the temperature of the generator is kept fairly low, then the formation of clinker is a minimum, but to get good, rich gas it is necessary to work at a fairly high temperature—say, at 2000 deg. F., and at this temperature a considerable amount of the ash is fused and forms clinker. In some cases this is of a highly vitreous nature, having an affinity for the firebrick lining and being extremely difficult to remove without breaking away portions of the brickwork to which it clings. Unless it is removed periodically, it causes arching over of the fuel similar to the action of caking coal, and poor gas is the inevitable result.

It is imperative, then, that with coal of a high ash percentage every facility should be provided for the thorough searching of the generator and the effectual removal periodically of the ash, where anything like continuous running is required. In most anthracite plants the poking of the fire and clinker has to be done radially from a door or doors in the side of the generator shell, near the bottom, but when clinker is adhering to the brickwork it is next to impossible to remove it without damaging the firebrick lining.

The position of the vaporizer in most suction plants is at or near the top of the generator, making difficult the best arrangement of poking the fire, namely, in a direction parallel to the wall of the generator. In one or two generators poke-holes are found in or adjacent to the fuel hopper, but even in this case the poker must point at an angle to the brickwork, although the angle is considerably smaller than in the case of radial poking near the bottom. To anyone, however, who has had the running of a suction gas generator on full load with a depth of, say, 5 ft. of fuel, the great advantage of being able to push the poker through the fire parallel to the firebrick lining and close up to the brickwork is at once apparent.

Anthracite plants of fairly large units, say of 200 brake horsepower and upward, are fitted with a water-luted ash tube, by means of which the ash and clinker after being poked down can be removed without seriously interfering with the quality of the gas produced. Since there is in most common slack steam coal a much higher percentage of ash than in anthracite, a similar means of removing the ash and clinker will be necessary for even smaller units than those mentioned, unless recourse is made to other means, such as mechanically operated slicers similar to those now made for pressure producers gasifying coal high in ash.

There are, of course, a large number of other combustibles which may be satisfactorily gasified in suction gas plants, from dried barnyard refuse up to charcoal, including a number of more or less waste products, such as sawdust, etc., but as these have only a limited sphere of distribution the greatest desideratum is a suction gas plant which will produce gas commercially successfully from a wide and extremely variable class of bituminous coal.

To summarize, then, the ideal suction plant will consume all the volatile matter contained in the coal in addition to the solid carbon, and to effect this requires an intimate mixture of air with each portion of the coal at a suitable temperature, to fulfill which duty some means of mechanical feeding of the fuel at a regular rate to suit the load on the engine would seem desirable.

Caking coal will be so treated as to prevent arching over and consequent obstruction to an equable air and vapor supply in the main fuel column of the generator.

Suitable facilities for the effectual removal of ash and clinker formed, without interfering with the quality of gas produced, will have to be provided for coal with a high percentage of ash, and, in fact, for all coal used on extended periods of running.

The amount of space occupied, simplicity of construction, with minimum amount of attention and reasonable first cost, are factors the stating of which, perhaps, savors of triteness.—*Engineering*, London.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Hot Water Heating for the Central Station*

By Ira N. Evans†

In an article published Sept. 12, 1911, the subject of the arrangement of heaters and pumps, etc., as well as the economies of hot-water heating were discussed. This applies to central-station heating for cities and towns as well as to the requirements of large institutions and manufacturing plants.

Many central-station companies where condensing conditions are favorable, have refused to consider heating on account of the possible interference with the economical operation of the engines for power; therefore central heating has to a certain extent been limited to noncondensing plants that were paying small returns or no dividends at all. The fact that the hot-water system can be operated successfully and economically in connection with condensing engines and turbines should broaden the field. The application of hot-water heating enables the exhaust steam from a large turbine to be utilized under partial vacuum without interfering appreciably with the economical operation of the plant for electric-power purposes.

In the case of large institutions and private plants the heating has to be provided and paid for by the institution or corporation itself, and it is a question simply of what is the most economical system both as to first cost and operation and no dividends are required. In commercial town heating the conditions are entirely different. These installations are made generally in connection with an existing electric-lighting station and the heating plant is required to pay a reasonable return on the investment. The companies are not obligated to enter the heating business unless an increase in net revenue on the entire plant is assured. Besides, the customers have to be attracted by a rate low enough to compete with the cost of heating by domestic coal.

It is very necessary to operate a heating plant in connection with the power load of an electric plant so as to arrange to use the exhaust steam and eliminate the boiler investment as far as the heating system is concerned.

In cases where the margin between the cost of domestic and steam coal is large, the heating plant might pay by itself and even then the power load would greatly increase the revenue.

Many promoters have advocated the installation of heating plants, stating that there was money in live-steam operation. Neither heating nor power should be considered as a byproduct. The heating plant should be made to stand alone and pay a reasonable return on the investment. The heating cannot be accomplished unless some economy is sacrificed on the power end. All excess steam utilized for heating over what is required for power under the most economical conditions is a charge against the heating plant as well as the interest, depreciation, maintenance of heaters, mains, etc., and the space occupied by the heating plant in the boiler and engine rooms.

In a temperate climate there are only seven months when revenue can be obtained for heating, while the interest charge covers the entire year. The first consideration is the price of domestic coal and its heat value as compared with the price paid for the coal used in the central plant, as this will indicate what charge may be made for heating dwellings. The power load on the plant, its duration and amount are also to be considered. Heating, if sold commercially, is required 24 hr. per day. The ordinary electric-lighting plant has a widely fluctuating load and is sometimes

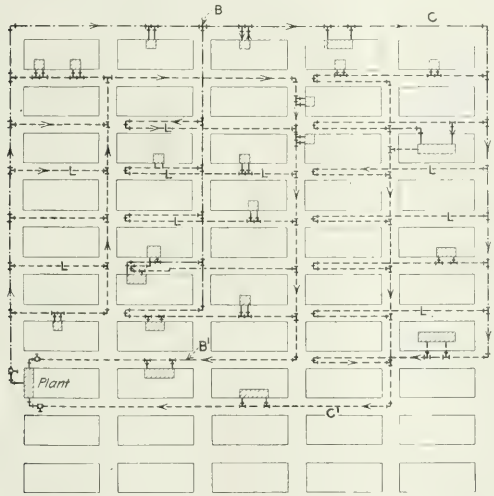


Fig. 1

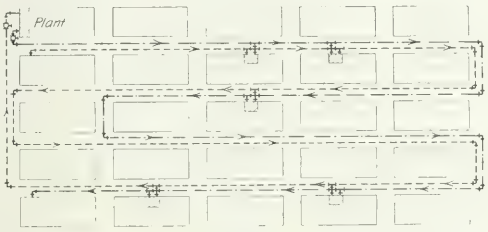


Fig. 2

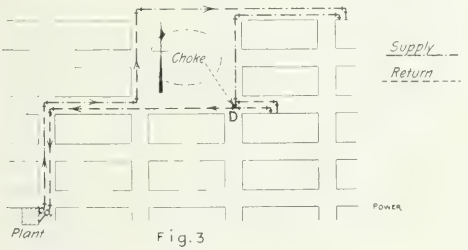


Fig. 3

Methods of Arranging Street Mains

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inoperative Sundays and at times during week days; at such times live steam has to be used for heating.

It is a great advantage to be able to furnish both heat and power from the same plant and many customers can be obtained at fair rates. If the heating were not furnished, isolated plants would be operated in many instances, and the power load would not be obtainable for the central station.

In the consideration of the best system to adopt in any individual case the following requirements should be fulfilled:

1. The system should be flexible, with as wide a range of temperature of the heating medium as possible to meet the varying outside weather conditions. This will enable the system to be operated on the minimum average temperature and steam consumption, without depending on customers to shut off the heating surface, thus eliminating waste by overheating. This is especially important when live steam has to be used during periods of light power loads. The water system can be absolutely controlled at the plant and a given amount of exhaust steam can be made to cover a greater territory due to the average lower temperature of the heating medium than when steam is used directly in the system. From a previous issue a table is given showing that the extreme weather in temperate climates only occurs about 25 per cent. of the heating season. The steam per hour required for the remaining 75 per cent. of the time, or average weather, is only 60 per cent. of what would be required in zero weather. Where steam is utilized at 212 deg. and a constant pressure, and the radiation is not automatically controlled, the steam consumption does not vary more than 15 per cent. between the maximum and minimum temperature outside during the heating season. The hot-water system shows a variation in steam requirements of 100 per cent. between the minimum and maximum outside weather requirements, and a change in the temperature of the hot-water system may be readily effected as the outside temperature varies.

2. The system should be so capable of arrangement as to absorb the heat from any source with economy, and in the case of the use of exhaust steam with a minimum increase in steam consumption for power and the least interference with the operation of the engines over summer conditions, when no heating is required.

3. The capacity should be ample to do the heating at all times without excessive temperature of the medium, and admit of arrangement so that different sections can be independently controlled at the power house within reasonable limits.

4. There should be a minimum loss in transmission and the system should be independent of grades as regards circulation.

5. The power of circulation should be independent of the temperature of the medium; that is, it should be capable of maintaining the same rapidity of circulation with the medium at any temperature. It should not be necessary to lower the temperature and pressure of the medium at the end of the line merely to produce more rapid circulation.

6. The probable repairs and cost of maintenance should be low.

7. The cost of the different systems should be compared as well as the probable operating expense; any excess in expenditure in first cost of one system over another should show at least 10 per cent. gross saving of that amount as an offset.

8. The number of kilowatts obtained per pound of exhaust steam when utilized on the heating system for different outside temperatures should be determined. A heating system might be economical in the use of steam, as far as the radiation is concerned, and the increase in steam consumption on the engine units due to the manner of utilizing the exhaust on the heating apparatus be excessive.

In the case of small plants where the distances are comparatively short and all existing installations steam, it might be inadvisable to use a water system. It is comparatively inexpensive to change a first-class low-pressure steam system to hot-water unless steam radiators without top connections are used, in which case the radiators have to be replaced. Where hot-water radiators or coils are already installed, the only requisite is the enlargement of the return pipes, and in the case of a single-pipe steam job the addition of the return connection to the radiators from the riser.

It will be found in practice where exhaust steam is to be used under very low pressures that considerable expense will have to be incurred to adapt existing steam systems of customers to operate successfully from a central plant. One installation with poor circulation may cause an excessive back pressure on the engines and make the entire system more uneconomical, due to the increased pressure and temperature of the steam.

In many cases the wasting of the condensation is considered more economical than the maintenance of an expensive system of return mains with attendant traps, pumps, etc.

Where the grades are favorable, so as to eliminate pumps or traps, the conditions warrant the return of the condensation by gravity, but they are seldom met in practice. These conditions are eliminated entirely on the hot-water system, as no steam is taken outside of the plant. The exhaust steam is utilized under partial vacuum between the engine and condenser in an exhaust-steam heater. The heating system is utilized as a condenser to the extent of its capacity at any time, reducing the load on the regular condenser by that amount. All units not required to furnish exhaust steam are turned into the condenser under full vacuum.

It has been found by experiment that, with a given amount of radiation on a heating system, the steam requirements in temperature and amount will exactly balance a given constant load on a turbine by simply changing the vacuum to suit the outside weather conditions according to a prearranged schedule. That is, with 70,000 sq.ft. of direct radiation on a town heating plant and 400 kw. load on a turbine, the exhaust steam under vacuums from 0 to 28 in. will exactly balance the heating requirements between 0 and 60 deg. outside temperature. The same power load may be carried on the turbine throughout the entire heating season, the heating system acting as a condenser and reducing the steam rate per kilowatt-hour as the vacuum is increased. All live steam may be utilized under boiler pressure in a separate live-steam heater, the condensation being returned by gravity to the boilers. The pumps should be of the turbine type, of sufficient capacity to keep the maximum drop in temperature of the water in the system below 20 deg.

If the radiation were increased 10 per cent. over the requirements of a low-pressure steam or vacuum system, the lowest vacuum in extreme weather would not be below 4 or 5 in. and with two pumps in series the turbine would never have to be operated on no vacuum or back pressure above atmosphere. Where a steam-heating system is considered in connection with a turbine installation, the 100 per cent. increase in steam consumption for power due to the total loss of vacuum at all times may be fatal to its financial success.

There is a mistaken notion that a pump alone on the end of a steam line will produce a vacuum. This is not true unless the steam is actually condensed. If the heating apparatus has not sufficient condensing capacity, cold water has to be added to increase the cooling effect. This water is allowed to overflow and is wasted unless make-up water is needed for feed purposes.

One of the first requisites for a proper vacuum system is a thermostatic or float trap or check valve introduced between the steam in the system and the vacuum in the return so that bypassing will be prevented and steam will not enter the return system. The vacuum on any heating system is therefore limited to the degree to which the piping system can be made air-tight, and by the condensing capacity of the heating surface at any time. When extensions are required on a steam system which is loaded to its capacity, a new line

of larger pipe has to be installed or the pressure has to be raised on the existing line. Increasing the initial pressure on the line raises the back pressure and corresponding temperature of the heating steam on the near-by radiation, causing extra expense in addition to that involved by adding the new heating surface.

It may be readily seen that 1000 sq.ft. of heating surface 2000 ft. away on a steam system will require a larger main or greater pressure than the same radiation 200 ft. distant from the source. The extra distance on a hot-water plant does affect the pumping capacity, requiring greater power, but does not affect the vacuum or back pressure under which the engine units are operating.

The question of back pressure and size of main practically limits the distance covered on a steam system with economy, while the only limiting condition on a hot-water system is the cost of mains against another plant nearer by. A vacuum produced on the end of a steam line would increase the velocity, but at the same time the volumes of steam at low pressures increase very rapidly, offsetting the advantages and increasing the size of mains for a given output. There are 26.8 cu.ft. of steam per pound at atmospheric pressure or 212 deg., and 19.4 cu.ft. per pound at 5 lb. pressure above atmosphere and 230 deg. temperature. Forty per cent. more area would be required at atmospheric pressure for the same output and drop in pressure than would be required for 5 lb. pressure; also 12 per cent. more heat would be radiated by the heating surface at the higher steam temperature and pressure.

The mains of a steam system radiate the heat at a temperature of at least 212 deg., while that of the water system varies from 100 to 200 deg., averaging about 40 deg. less, depending, of course, upon the installation. The removal of condensation from the steam mains through traps is necessary to prevent water-hammer and involves considerable loss that does not occur with the water system. Customers do not have to bother with valves or air valves on the radiators and the disagreeable odor of cylinder oil so much in evidence when exhaust steam is used directly in the system is eliminated. The snapping and cracking of pipes so familiar to all is absent and also keeps the repair bill of the water system low. To make a central heating plant successful, every corner must be guarded, and frequently it is the small economies that place the plant on a profitable basis.

A hot-water system may be extended by adding mains, heaters or pumps without abandoning existing apparatus. Separate mains may be extended to new districts and the distance will not increase the size of the main on the water system in anywhere near the ratio that would be necessary in a steam system. Where a section is overloaded the circulation may be increased by a small booster pump placed in that particular circuit out on the line and operated by current from the main station. The increased velocity will carry the extra heating surface at slight expense without enlarging the mains.

The central hot-water heating plant should have recording thermometers on the supply and return mains and on the steam spaces of the heaters, as well as a recording venturi meter; with these instruments an exact record can be obtained of the output of the heating system in heat units. With an exact knowledge of the cost, a flat rate per square foot of heating surface per season can be charged, which is more satisfactory than meters or other devices.

All heating surface should be so carefully proportioned that a few radiators will not require that the whole system be operated on higher water temperatures. All pipes and connections in the power house should be arranged so as to make it easy and convenient to change the vacuum and water temperatures or the economy will suffer. A careful schedule of operation and a recording thermometer for the outside temperature should be provided, the schedule being checked with the required temperature of typical rooms on the system at frequent intervals. The water in the system should be changed as little as possible and all leaks should be investigated and repaired at once, as an exchange of water in the system is likely to cause the piping to pit and deteriorate. The use of a cooling tower and the furnishing of domestic hot-water supply utilizing the same water is liable to cause deterioration, due to the introduction of new make-up water.

All condensing apparatus should be entirely independent of the heating system as far as water connections are concerned. Pumping against the static head of the system is bad practice, as even when the apparatus is not very high it adds just so much unnecessary head.

Placing the expansion tank in the power house is the most satisfactory arrangement, inasmuch as any change in head or loss of water in the system is immediately detected.

The central-station man considering the addition of a heating plant cannot study the situation too closely, keeping in mind the important fact that the investment must be kept as low as is consistent with good workmanship and first-class construction. Spreading promiscuously all over the town must be avoided and only just sufficient mains should be installed to utilize the available exhaust steam to the best advantage. The use of hot-water boilers should be avoided and the live-steam heater should not be eliminated by introducing the live steam into the exhaust-steam heater through a reducing valve, as this method is uneconomical in operation.

It is impossible to regulate with great accuracy the temperature of the water in the case of hot-water boilers, as the grate surface necessary to heat sufficient water in zero weather would be 40 per cent. too much when the temperature ranged between 30 and 40 deg. F. Consequently the water would be too hot or too cold, and by attempting to cut boilers in or out of the system coal is wasted. Besides, there would be an extra investment in boilers. A motor-driven pump and a steam-driven pump should be used, either capable of carrying the entire plant, with connections in series so that both can be operated in extreme weather if desired. The motor-driven pump may be operated with current from the large unit furnishing steam for heating at a cost of not over 25 lb. of steam per kilowatt-hour. The ordinary vacuum pump on a steam system requires about 150 to 160 lb. per kilowatt-hour and the exhaust from these pumps cannot be used on the heating system to the same advantage as the steam from the pump on the water system. This means that six times the power can be used for circulating the water system at the same steam consumption as would be required for a vacuum system.

It is very bad practice to regulate the temperature of the water system by varying the speed of the pump, as it simply means a higher initial temperature of the outboard water, thus reducing the amount of vacuum and reducing the power obtained from the steam used for heating.

All underground work should be installed in a thoroughly first-class manner. The mains should grade up in the direction of the flow, with proper provision for the relief of the air automatically at all high points.

If the ground is dry and the subsurface well drained, wood stave covering may be used for conduit. If the ground is wet or moist, this type of conduit will deteriorate in a very short time. Tile pipe with chairs and rolls with hub and spigot joints set with cement make the best construction. The pipes may be packed with cheap nonconducting material, and as there are no drips, traps, etc., required, the space around the pipe can be kept perfectly dry. Manholes of brick with cast-iron covers should be used at each expansion joint, anchor and house connection. Expansion joints should be placed every 200 ft. with an anchor between, of a channel or I-beam laid on its side and bricked in solidly into the brick walls of the manholes.

House connections can generally be combined with the anchors and expansion joints in the same manholes. Packed sleeve expansion joints are apt to give trouble unless the bolts are gone over frequently to take up on the packing.

When the pipe contracts, it compresses the packing, and when it expands, the joint leaks, as the packing is not sufficiently resilient. This can be overcome by using a joint with a double sleeve, one held by heavy springs which keep the packing compressed under all conditions; this joint, however, is very expensive. The wear on an expansion joint in a hot-water system is far greater than when steam is used, as the temperature of the water is varied continually with the outside weather while the temperature of the steam is fairly constant. U-bends or a break across the street and back at intervals have been used with success and this method is inexpensive.

Flanges should not be used on underground work except in manholes as provision has to be made for the movement of the pipe; good wrought-iron couplings are preferable. In many town heating plants the shunt system has been found very advantageous as it only requires a single pipe and the entire distance up to its capacity can be utilized for service connections, especially where the pipe supplies through one street and returns through another. It is sometimes customary when house connections are large to reduce the main one size between the supply and return house connection, introducing friction. This will materially reduce the size of pipes required for the house connection by increasing the velocity in the shunt. Care must be exercised, however, that the capacity of the main for the remainder of the plant is not interfered with by reducing the size of the main at too many points. Y-branches have proved of no advantage in this work and only complicate the construction. Long-turn elbows and bends and double-sweep tees are of advantage on the mains, especially where high velocities are maintained. Reducing fitting with cored outlets should be avoided due to the loss in head. Radiator connections may be made with short-turn ells as the velocities are comparatively low; extra-heavy nipples should be used in all cases on water systems, especially for small sizes.

The price of heating in most parts of the United States cannot exceed 25c. per square foot of radiation per season without prohibiting its use by customers who do not feel able to pay for the convenience.

Fig. 1 shows an arrangement of street mains which will work out very economically for a compact district, and the arrangement permits readily of future extensions. If the supply and return are installed to *B* and *B'*, the full length of the main is available for shunt connections and *C* and *C'* can be added later. The branches *L* need not be installed until customers require connections. This system gives a pipe in each street and supply and return connections can be made where a large amount of surface may be required to be added for any individual customer, reducing the size of the house main over what would be required if operated on a shunt system.

Fig. 2 shows a system with a supply and return in each street. The house connections here can be made smaller and lower velocities can be used on the main, reducing the friction head on the pump.

Fig. 3 shows a shunt circuit for a small installation where only a portion of the town is covered and some of the service is a considerable distance from the plant. A valve at *D* forces the water around the branch circuit. All house connections would be made in shunt. A smaller main would be required than for a supply and return system and a higher head would be required on the pump, due to the greater velocity. Where the exhaust steam from the circulating pump can be utilized the operating expense is less than the interest on the investment in long mains of greater diameter. Where a proper velocity is maintained on the main, a 2-in. pipe will take care of 1000 to 1200 sq.ft. of surface on a shunt circuit. All branches to buildings should be covered with sectional covering. An efficient and cheap method is to use $\frac{1}{32}$-in. asbestos paper cut in rolls 6 in. long and wrap it around the pipe spirally until there are several thicknesses.

The following data were obtained from a plant installed some time ago which has been very successful financially and was arranged similarly to the system shown in Fig. 3. This plant is run noncondensing and has a capacity of 200 hp. The engine is of the Corliss type, using about 28 lb. of steam per horsepower-hour. There are 28,000 sq.ft. of heating surface on a 5-in. circuit, all connections being in shunt. There are three 3-in. shunts off the main, which is about ¾ mile in length. A 12-hp. pump is used to circulate the water and the usual exhaust and live-steam heaters are installed. The pump maintains a difference in head on the circuit of 20 lb.

A charge of 15c. per square foot of radiation per season is charged to all customers and coal costs $1.69 per ton delivered in the boiler room. The total income from the heating plant is $4200 on 28,000 sq.ft. of surface. The amount of coal chargeable to the heating service, including Sundays, when the engines are shut down, is about 300 tons per season, which would amount to $500 and leave $3700 to cover the interest on an investment of $15,000, depreciation, etc.

The question of extending this plant came up and it was decided not to increase the plant further than there was exhaust steam from the power load to supply heat. The investment in mains and extra boilers for live steam for heating purposes, unless additional power load was available at the same time, made it inadvisable.

It is very important to obtain a day load, and in many small towns manufacturers can be induced to locate if they can obtain both power and heat from an outside plant. A considerable day load can be attracted by lowering the rate somewhat. Electric power should not be sold at a loss simply to obtain exhaust steam for heating, and the heating should not be placed below cost simply because the exhaust steam may be a byproduct. In any case, considerable live steam has to be used on periods of light power load to supplement the exhaust steam, and this charge becomes greater with the size of the system. On the plant referred to there is an average day load of 150 hp., which takes care of the heating until the weather gets below 10 deg. outside.

The buildings may be piped from a supply main looping the basement, with the first-floor radiators shunted off direct and the two upper floors supplied by separate risers. For buildings over three or four stories an overhead system is preferable, with single risers connected to the return in the basement. The radiators may be shunted off the riser from two tees 2 ft. apart. In Figs. 1 and 2 proper circulation is effected without the use of choke valves on house connections. These should be avoided and will not be required in the building mains if the piping system is designed properly.

LETTER

Cause of Pump Racing

I have had trouble similar to that described by Mr. Moulton in the Apr. 2 issue and I believe it is due to generation of vapor in the water cylinder of the pump during a quick reduction in pressure in the heating system. I would suggest that he reduce the steam pressure on the system very gradually when cutting it off, and in that manner keep the temperature of the water cylinder and the system more uniform; in other words, let the pump cylinder cool down with the system.

C. H. Wilson.

East Orange, N. J.

The comparative fuel cost at the Port Henry (N. Y.) power plant, according to the *Engineering and Mining Journal*, is as follows: 11 tons of No. 2 buckwheat (anthracite) worth $2.65 per ton at the plant, is equal in heating value to 10 tons of bituminous, at $3.92 per ton, or $29.15 worth of anthracite equals $39.20 worth of bituminous coal, thus making the cost of operating with bituminous 1.345 times more than for anthracite.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROBT. MCKEAN, Sec'y
505 Pearl Street, New York.

Monadnock Blk., Chicago
6 Bouverie Street, London, E. C.
Underden Linden 51—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Give Authority to the Public Service Commission

Destructive competition in public utilities is manifestly a bad thing, but in return for a franchise virtually granting a monopoly in any city, a public-service corporation should willingly submit to regulation by the proper authorities.

Hearings in the rate case against the New York Edison Co. have been dragging on before the Public Service Commission for several months and now that a new petition has been introduced (as announced by us two weeks ago) the indications are that another equally long period will be required. At the first hearing under the new petition, in answer to a request for the number of consumers in each class and the amounts received from each class during the past three years, Mr. Hemmens, counsel for the New York Edison Co., announced that the company did not intend to give out any information further than that included in its annual reports to the Public Service Commission. As is well known by anyone who has attempted to make use of these reports, they are not in such form as to permit of definite deductions.

If this is the attitude of the New York Edison Co., it would seem almost useless to proceed further with the hearings until the status of the commission, relative to its power to compel witnesses to answer pertinent questions, is determined. Repeatedly during the former hearings the commissioner ordered the witnesses to answer certain questions, whereupon counsel for the defendant instructed them not to answer. Needless to say, the witness always followed the dictation of the counsel in defiance of the commissioner, and the latter was apparently powerless to take any action.

The New York Public Service Commission for the first district alone costs the state over one million dollars annually, an amount in return for which the people have reason to expect results. If the commission is to be of real service to the state, it should be granted full powers to investigate and get at the bottom of all facts pertaining to complaints brought before it.

The good work that has been accomplished by the Wisconsin Railway Commission forms a precedent and shows what can be accomplished in the regulation of public utilities where the commission is vested with the necessary authority. Why, then, should not New York follow the excellent example set by Wisconsin?

Competition

In the power plant, as in all nature, the struggle for existence is daily becoming more and more acute. Usually, the fittest survive and the weaker perish, the individuals who exert little progressive effort being soon relegated to insignificance.

The plants that through mismanagement are high in operating costs must sooner or later be displaced by central-station service. There is perhaps no other good reason for central-station service shutting down an isolated plant of ordinary output. Local conditions, such as close proximity to a hydro-electric station, where the cost of current generation is exceedingly low, may determine the advisability of closing down an isolated plant, but generally the properly managed isolated plant can survive the persistent competition of any central station.

Deep in the consciousness of most engineers lies the knowledge that central-station service would mean a great decrease in the operating costs of hundreds, even thousands, of power plants. Central-station men also clearly realize this, and hence the logic of their arguments in their relation to such plants. Engineers in charge of these excessively high cost plants know, or surely ought to know, that it is only a matter of time when the forcible talk of the central-station solicitor, substantiated by figures.

and other data, will convince the management that its power division is a source of heavy loss and a contributory cause of low dividends.

Once convinced, the isolated plant must go because modern business cannot, and will not, tolerate a remedial loss. The engineer's only hope then is to prevent the management from becoming convinced. He must not expect to achieve this by mere emotional or persuasive argument. That day is past. Argument by conviction, which calls for worthy evidence, must be made to be effective.

To obtain such evidence means a close study of modern power-plant management, the systematizing of the operating work, and, above all, the use of records particularly adapted to each department of the plant. While this adds to the duties of the engineer, the conditions demand it, and the key to survival is in adapting the plant to the conditions.

Unnecessary Risks

While sometimes in power-plant practice it is necessary for the continuation of service to assume grave risks, more often it is foolhardy. It should be remembered that men who assume these risks not only jeopardize their own lives and limbs, but in most cases those of others in the immediate vicinity are also endangered. The man in charge should therefore use much discretion in allowing his subordinates to do such work.

For instance, an exceedingly long-handled wrench should not be used to tighten the defective and leaky caps on water-tube boilers under high pressure. No harm will be done if all the parts are sound but too often they are defective.

The practice of assuming that the physical condition of the boiler will admit of more heavily loading the safety valve and that it and the steam gage are correct, is poor engineering; such things should be accurately ascertained, not taken for granted.

It is also unjustifiable to risk putting water into a boiler in which the attendant does not know how far below the bottom gage-cock the water has gone. Happily, this is done but infrequently. It is better in such cases to cover the fires, taking no dangerous chance just because the attendant fears being discharged, which is his only reason for assuming the risk. His life and that of others are more valuable to the community than his job. It is also wrong to send men into a hot boiler shell into which a great volume of steam is pouring through the dry-pipe, without posting someone on the outside to play cold water into the boiler and to observe and assist them if they collapse.

No meager amount of discretion should be exercised in deciding how long a serious leak on a high-pressure line of any kind should be allowed to continue before its repair. The practice of entering the ashpits under a bright fire to repair a section of the broken grate bars is also to be condemned. To work on a closed high-tension electric circuit "just to save time" is nothing short of suicidal, but it is done now and then.

All of these things are commonplace, but it is just as criminal to assume unnecessary risks in performing them as it is to allow an intoxicated man to take charge of the equipment.

Perhaps most important of all to conservative practice is to keep uptodate and be at all times conscious that operating engineers are in charge of the basic thing upon which all modern industry depends for its existence and continuity—power.

Commendable Loyalty

Disregard for the peculiarities of human nature is often responsible for the complete failure of ideas that might otherwise have proved productive of good results, as the following case well illustrates.

The plant is one of the largest in the East, its management, all things considered, is admirable, and the chief engineer is thoroughly competent as the success of his department attests.

As the manager desired more coöperation on the part of the men, he requested that if any of the employees had ideas which they thought would improve the plant's operation, he wished that they would report them to him. No mention was made of the chief engineer.

One by one the men read the notice, smiled, and walked away. The manager did not receive one reply to his request, and perhaps he is still wondering why. The only comment of the men was that they would not ignore their superior, the chief, by carrying their suggestions beyond him to the manager. With this type of men much can be accomplished if they are properly handled.

The Smoke Inspector in Trouble

The labor difficulties in the coal fields both here and abroad have made the smoke inspector's task, which at no time is a sinecure, particularly arduous. The strike in England has led to the exportation of practically all the better-grade coal mined in the vicinity of the seaboard. Because of the threatened trouble here the balance of such coal has been bought either by the railroads or by the large consumers and as a result none can be secured in the open market.

This makes it necessary to burn low-grade fuel in a large number of plants not suitably equipped. The consequence is much smoke which the inspector is helpless to prevent, for it would be unreasonable to require a change of equipment because of this temporary condition of the market. On the other hand, the general public, entirely ignorant or thoughtless of the underlying cause, rails at the dirty condition of the city's atmosphere and unjustly condemns the smoke inspector as incompetent or worse.

Returns to Engineering

Cecil P. Poole, for the past seven years junior editor-in-chief of POWER, has resigned that position in order to engage in consulting engineering. He will enter into partnership on May 1 with Lamar Lyndon, of New York, and the headquarters of the new firm will be located at Atlanta, Ga. Mr. Lyndon's New York office will be continued as heretofore and will coöperate with the Atlanta office, which will be conducted by Mr. Poole.

During the past 12 years Mr. Poole has specialized in the design and construction of electrical machinery and in gas-power engineering in general, and the information and experience accumulated during that period should be of much value to him in the line of work he is now entering.

He carries with him the best wishes of POWER, and of the members of the staff with whom he has been so pleasantly associated, for an abundant success in his new field.

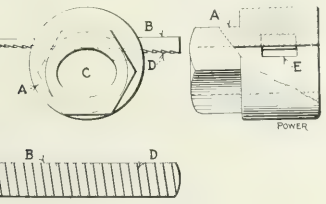
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Stud Extractor

The accompanying illustration shows a home-made stud extractor and driver. This device will be valuable to any power plant.

In the illustration, *A* is a bushing nut,



STUD EXTRACTOR

B is a wedge, *C* is an oval hole, and *D* are teeth on the wedge to prevent slippage between the stud and the wedge.

With this extractor three sizes of studs may be extracted or driven with one wedge.

J. G. KOPPEL.

Montreal, Can.

Steam Consumption of Compound Pump

An engineer asked me why a duplex compound pump took more steam when running with the cross exhaust open than when running with it closed. I replied that I did not know that it did.

He then stated that when running a large elevator pump, and the boilers fired with gas, he found that when the gage indicated 100 lb. pressure with the

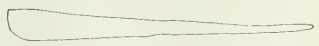


FIG. 1. VALVE CLOSED

FIG. 2. VALVE OPEN

cross exhaust of the pump open, the steam pressure would increase to the blowing-off point if the cross exhaust were closed. This had been tried over and over again, and he got the same result each time.

I determined to find out if this were so and went over and had a look at the old 10, 16 and 10 by 10 pump that I had been running for years. I knew that when I closed the valve in the cross exhaust the pump made a shorter stroke than when the valve was opened. I had been told to run with the valve one-quarter open and I had done so without thinking of the reason why, just as we often do. As the cylinders were tapped for the indicator, I proceeded to investigate. Diagrams were taken from the high-pressure cylinder, but they shed no light on the subject, but on shifting the indicator to the low-pressure cylinder the reason for greater steam consumption was apparent.

The diagram taken with the cross exhaust closed is shown in Fig. 1; that with the exhaust valve open is shown in Fig. 2.

With the valve closed the low-pressure cylinder gets steam only from the high-pressure cylinder on that side, but with the valve open it got more steam from the other side, when near the end of the stroke. This produced a longer piston stroke, due to the higher pressure, and a higher exhaust pressure when the exhaust port was opened to the atmosphere; consequently a higher steam consumption.

E. J. SAXE.

Christopher, Ill.

Why Two Engineers Did Not Get the Positions

In a certain town of about 5000 people the lighting plant employed three engineers. The chief had the shift from 7 a.m. until 5 p.m., and did his own firing, but the load was light and he had plenty of time for the other work.

The company paid good wages but the manager did not believe that paying a $75 man $100 would make a $100 man of him.

The manager was looking for the latter priced man, but had the place temporarily filled by an $85 man. On one occasion this man was ill and an ice-plant engineer was secured, his plant being temporarily shut down. He came highly recommended and the manager was glad of an opportunity to learn more of his ability.

It was customary to weight the coal used and report the quantity consumed during each six-hour period. The coal was unloaded from the cars and piled near the boiler house and each engineer wheeled his own coal. The manager required the engineers to always use from the oldest pile, and by unloading each new car of coal on a separate pile the manager was able to check the engineer's weights against the mine weights, and also tell within a ton the amount of coal on hand.

The ice-plant engineer, although knowing of this rule, used from the new carload while there was still some left on the old pile, because the former was nearer and he was not going to wheel coal any farther than he had to for anybody.

There was another engineer in this town who had asked the manager for a position and his application was put on file. In the meantime this man obtained a position that would only last a few months, running a new engine.

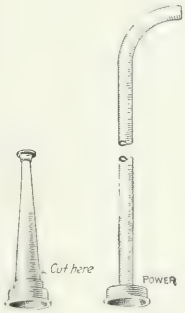
Shortly after this, two vacancies occurred at the light plant. Remembering the incident of the coal pile, the manager promptly turned down the ice-plant engineer's application for the position of chief engineer, and on visiting the other engineer he found the new engine covered with dirt and the floor wet with oil. Other men got the positions, and no wonder.

G. E. MILES.

La Jara, Colo.

Boiler Washing Tool

An old hose nozzle cut off near the big end and tapped out for a ⅜-in. pipe, which can be supplied of a suitable length to fit the conditions, makes one of



BOILER WASHING TOOL

the handiest tools for washing return-tubular boilers.

I use one with the end of the pipe bent to an angle of 90 deg., as shown in the illustration, and can reach almost any part of the boiler.

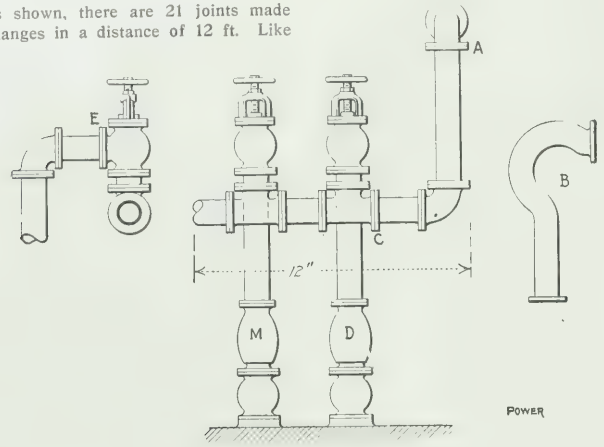
A. G. KNIGHT.

Omaha, Neb.

Eliminating Joints

The arrangement of steam piping in many power plants leads to the belief that the engineer or someone connected with its general plan has some interest in the manufacture and sale of fittings. The accompanying illustration is an example of such steam mains.

As shown, there are 21 joints made by flanges in a distance of 12 ft. Like



SHOWING SUPERFLUOUS JOINTS

many lines, the covering is only put on the steam pipe, the uncovered flanges acting as a "radiator." Many of the joints could be omitted and a special bend could be made as shown at *B*, which could reach from the point *E* to points *M* and *D*. The same could be done from the flange *A* to *C*.

C. R. McGAHEY.

Baltimore, Md.

Costly Negligence

My experience may serve to illustrate the importance of a thorough inspection of the interior of boilers before they are closed up and put into service after undergoing cleaning or repairs.

I had been in charge of this plant only a few days when I saw, in the furnace of a return-tubular boiler, a bag about 2 ft. from the girth seam in the front fire sheet. The boiler was taken off the line as soon as another boiler could be connected. The next day, on entering the damaged boiler I was surprised to find a burst sack of sand lying across the tubes about one-fourth the distance from the front head.

The circulation had scattered it more or less, but there was a fair-sized pile over and surrounding the place where the bagging had occurred. The bag was so bad that I had the piece cut out and a hard patch put on rather than try to hammer it up.

ROBERT TOMLINSON.

Chicago, Ill.

Cutting and Applying Gaskets

In applying a gasket to a flanged joint, I find it better to cut the gasket to fit inside of the bolt-holes when possible. This will give a better chance to draw the flanges together and the gasket will not be as liable to injury, caused by the cutting of bolt-holes, which are hard to get exactly in line with the holes in the flange. If the holes are not in line, the gasket will be strained in places, causing weakness.

One should always be very careful to use as thin a gasket as possible; it will give less chance for the action of steam or water on the joint.

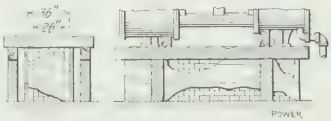
When a joint is to be broken often, one should apply a mixture of graphite and cylinder oil to the one side of the joint to keep the gasket from sticking to both surfaces.

J. ALTON BARRICK.

Kenmare, N. D.

Pump Foundation

In one plant a new service pump was installed, as the old one was too small to supply the increased needs. When the new pump arrived measurements were



REMODELED PUMP FOUNDATION

taken for the proper fittings; then the old pump was removed and the new one was placed on timbers ready for it, as shown in the side and end elevations.

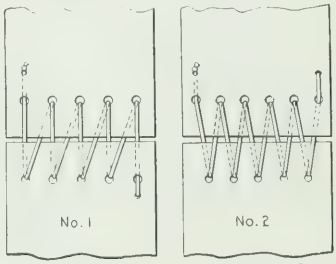
The old foundation was left standing and a wooden form was built around it large enough to accommodate the new foundation for the larger pump; then the anchor bolts were placed in position and the form surrounding the old foundation was filled with concrete. After the concrete had set, the timbers and form were removed and the foundation was smoothed off with a trowel and mortar to give it a finished appearance.

JAMES G. SHERIDAN.

Brooklyn, N. Y.

Eliminating Belt Troubles

Having experienced much trouble with belts laced as shown in No. 1, a relief was sought by lacing all belts as shown in No. 2.



ARRANGEMENT OF BELT LACING

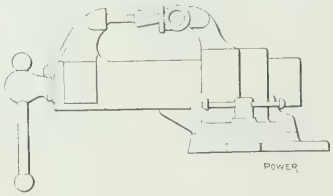
When laced as in No. 1, the lace holes in the belt persisted in tearing out, especially on the left side. When the improved method was tried this trouble ceased.

HARRY D. EVERETT.

Fort Apache, Ariz.

Removing Broken Pipe Ends

The removal of broken pipe ends from fittings, which is usually a troublesome job, is made quite easy by driving a cape-chisel into the broken end, but in-



POSITION OF CHISEL AND FITTING IN THE VISE

stead of placing the fitting in the vise, the point of the chisel is so placed and the fitting is turned.

With fittings where the point of the chisel cannot be grasped, the vise should be opened wide enough to have one jaw press against the head of the chisel and the other jaw against the fitting, as shown in the illustration. I have used both methods with excellent results.

A. T. KASLEY.

Swissvale, Penn.

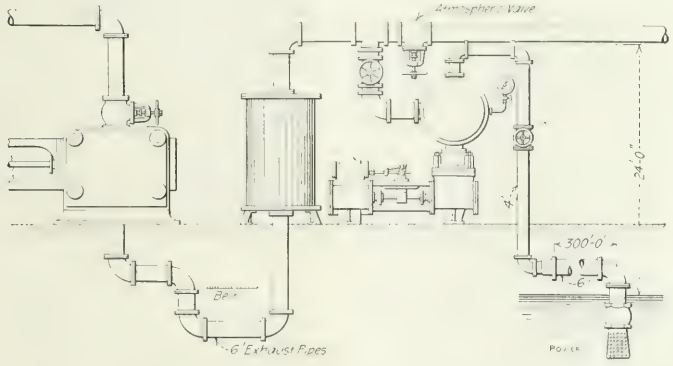
Troublesome Condenser

The accompanying illustration shows a condenser and engine in an electric-light plant. The condenser was recently installed but it fails to work; it will not hold the vacuum when the engine is running and will only pull 24 in. with the engine cut off from the condenser.

It is 300 ft. from the condenser to the lake, and the lift is 24 ft. There is no automatic relief valve to the atmosphere, just a common disk valve. What would be the result if the condenser should lose its vacuum while the engine was running? I would like to hear from POWER readers on this subject.

B. A. JACOBS.

Frankfort, Mich.

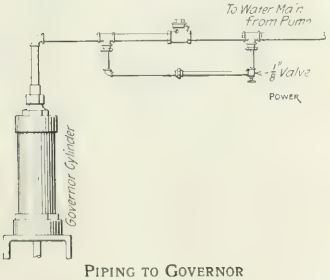


ARRANGEMENT OF CONDENSER PIPING

Pump Governor Trouble

A duplex pump, with a suction pipe 125 ft. long, gave a very uneven discharge which seriously affected the operation of the throttling governor.

To overcome the trouble the governor connections to the discharge were changed to the arrangement shown in the illustration. The water then had a free passage to the governor cylinder through the check valve, but in returning it must pass through the ⅛-in. line and angle valve. By adjusting the valve the governor can be made to operate without excessive fluctuation, and the pump can be run steadily and without noise.



PIPING TO GOVERNOR

H. L. BURNS.

Mayville, N. D.

Loose Locknut Causes Wreck

The piston rod screwing out of the crosshead caused the piston to butt out the cylinder head and break a piece out of the cylinder and steam chest about 4 in. long and about one-third the way around the upper side.

The engineer had taken out the piston the day before the wreck to replace a broken ring and failed to make the locknut tight enough on the rod next to the crosshead. The engine ran smoothly for four hours up until about a minute before the wreck, when it began to pound, the piston striking harder every revolution. The engineer ran to the throttle and closed it just as the wreck happened.

The engine is an 8x12-in. slide-valve, running about 240 r.p.m. at 130 lb. gage and was used for threshing grain and running a portable sawmill. It had been in service about four years.

M. W. UTZ.

Minster, Ohio.

What Causes the Sediment?

We have been experiencing much trouble with our feed water, which contains a large amount of very fine red sediment. Before being heated in the boilers the water is clear, but when it is heated the sediment settles and is very hard to wash from the boilers. When the blowoff is opened the water issuing forth is almost blood red. Surface water is used.

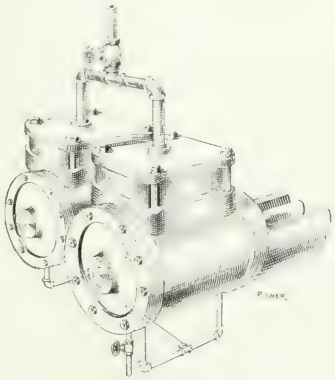
The boilers are blown down every morning and washed thoroughly every week. As we do not know the cause of our trouble, we trust some fellow engineer may help us.

W. V. KING.

Seymour, Iowa.

Pump Drip Piping

A few days ago I was called to look at a feed pump that would not pump water into the boiler, but would pump it into a tank. The pump was new, and for the first two or three weeks it worked all right. I told the engineer to start it up and let me see what it would do. He started pumping into the tank. After it was running he reached down and closed the drips on the steam cylinder, but he only shut one valve. I looked at his piping and found that he had connected all of the drips to one pipe with a valve on the main drip pipe.



PIPING OF DRIPS

I put a valve on the drip of each cylinder. After the change the pump worked properly.

FRANK H. CORDNER.

Bradford, R. I.

Where Should the Coil Be Placed?

I would like to hear from POWER readers who have had experience with a coil placed at the rear end of a horizontal tubular boiler, for the purpose of heating water for domestic use, such as washing and cooking.

What material should be used, and is there any danger of explosion of the pipe; also, what precautions should be taken, and what method used in piping it up? What is the best location for the coil to obtain the best results?

Stewart, Nev. ANGELO BELMONTE.

Priming Centrifugal Pumps

In our plant we have two turbine-driven centrifugal pumps which are located above the hotwell from which they take the discharge from the condenser and raise it to a tank on the roof. An injector is used to prime both pumps and proves much more practicable than the small service pumps formerly used.

HERBERT LEIGH.

North Andover, Mass.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Effect of Air in Steam

Referring to W. A. Fullgraf's question in the issue of Mar. 26, my experience has been that a leaky suction on the boiler-feed pump will greatly impair the vacuum in a condenser. I had one case where the vacuum dropped to 22 in. and after searching for the cause, I found a leak in the valve stem of a globe valve located in the suction pipe of the feed pump. Shortly after tightening the gland nut the vacuum rose to 25 in.

I think a leak here gives more interference with the condenser's operation than one of the same proportion in the condenser air pump, owing to the air increasing in volume on account of the higher temperature in the boiler.

H. R. ROCKWELL.

Alton, Ill.

Too much air in the steam would destroy the vacuum. The amount necessary to seriously interfere with the operation of the condenser will depend entirely upon the type of condenser and the conditions under which it works.

It is doubtful if enough air could enter the feed pipe to give trouble, especially if the pump had to lift its water; if the leak was great enough the feed pump would not lift the water. If the water flowed to the pump by gravity the water would leak out and the air could not leak in. Under such conditions the pump would pound so badly that it would be necessary to stop it.

Condensers will not work satisfactorily if a large volume of comparatively cold air is admitted to them, as in the case where a freshly fired boiler in which the air has not escaped is cut into service.

L. JOHNSON.

Exeter, N. H.

Air in the steam will, when steam is discharged into the condenser, turn it into water, leaving the air in the condenser, and partially, or wholly, according to the amount of air, destroy the vacuum.

Pumping air into the boiler because of a leaky feed-pump suction, means the enlargement of the original volume of the air in proportion to the temperature to which it would be raised, which would be the temperature of the steam.

A leaky circulating pump would have no effect on the vacuum at all, unless it were large enough to prevent the pump from delivering the required amount of circulating water. On the other hand, if there was a leak in the air pump, it could have no direct effect on the vacuum, as it would not admit air into the condenser, but would simply minimize or totally destroy the serviceability of the air pump, thus preventing the air from being removed from the condenser and consequently destroying the vacuum.

VICTOR BONN.

New York City.

The most annoying leaks affecting the vacuum in condensers are those in the valve stems and flanges of the exhaust main leading to the condensers. These leaks are easy to find by applying a candle flame at the joints, as the flame will be drawn inward if a leak exists.

In cutting in a boiler where no provision is made for the air to escape as the steam pressure begins to rise, it will be noticed that the vacuum will quickly drop from 5 to 10 in., depending on the amount of air in the boiler and on the kind of condensing system.

I cannot see how an air leak in the suction pipe of a feed pump, the leak not being sufficient to prevent the working of the pump, could reduce the vacuum in the condenser more than 1 in. at the most, as it would immediately pass from the boiler with the steam and in such a small quantity that the average jet condenser could take care of it.

A surface condenser having an air pump in addition to the circulating pump could take care of a considerable volume of air without any noticeable effect on the vacuum. I have had a large duplex pump feeding eight boilers where the suction pipe leaked so badly at the joints that if it were slowed down to half speed it would lose the water and have to be primed to get it started again. A jet condenser was used and the gages indicated 25 in. of vacuum, while the highest vacuum obtained under full load and normal conditions was 26 in.

R. A. CULTRA.

Cambridge, Mass.

Air in a condenser is the chief obstacle to obtaining a high vacuum, regardless of the manner in which it found its way in. If it comes in with the steam, it is at a high temperature, but not any higher than that of the steam in the condenser. If it enters through a leaky circulating pump it mingles with the steam and reaches the same temperature in a very short time.

A leaky air pump would be a greater source of trouble because it could not be depended upon to remove the air from the condenser and maintain a high vacuum. If the feed pump lifting the feed water leaked to any extent, it would soon show by refusing to lift the water, especially if the feed was rather warm, thus making the chances of carrying a large quantity of air over with the feed rather doubtful.

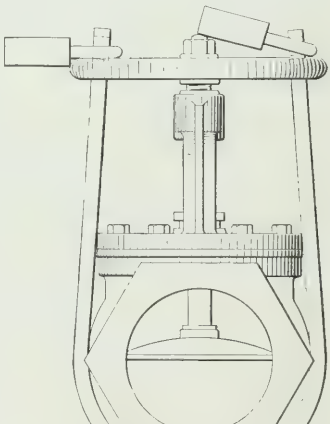
M. S. WEIL.

Philadelphia, Penn.

Valve Locking Device

The locking devices described by John Thorn in the Mar. 12 issue remind me of a locking device that I have used with success on blowoff valves and feed lines.

I had been having considerable trouble with the engineer boys that were in charge of the different plants under my supervision. They would first flood the



boilers and then some of them would naturally open the blowoff valve in order to drain off some of the water. Other boys would run to notify me and they would sometimes get me up in the middle of the night. Finally, one night they ran one boiler dry. Of course, this meant extra work for me, expanding tubes and calking seams. Right after that, I got busy scheming up a locking device. The

one I use is shown in the accompanying figure and consists of an iron strap bent into a U-shape. This passes around the body of the valve and through the handle. A lock at each end keeps it in place.

ANGELO BELMONTE.

Carson Indian School, Stewart, Nev.

Gage-Glass Fracture

The gage-glass fracture described by Richard Swartz in the Mar. 26 issue has happened many times.

In blowing steam through the glass to clear it of sediment, it is possible that a small piece of scale or other hard substance is detached from the pipe leading to the column, and, as the steam assumes a circular movement in rushing through the glass, it carries the hard substance in question with it. The probabilities are that the substance will follow the inner surface of the glass, slightly scratching it, and engineers know what a slight scratch is required to cause a gage-glass to crack.

JOHN THORN.

London Junction, Ont.

Gage-Glass Background

In making a background for a water gage-glass, I have found the following method to give good results:

Cut a piece of tin or other bright metal to fit in back of the gage-glass. Then polish the surface that is next to the glass, after which paint black strips ¼ in. wide and ¼ in. apart so as to stand about 45 deg. with the plate in a vertical position. The space above the water line will then show the correct angle of the stripes, but those below the water level will appear at a different angle.

Another good way is to paint a ¼-in. stripe running the full length of the background, and located directly back of the glass. Above the water line the stripe will appear normal, while below it the stripe will widen to the size of the glass.

O. L. SHERMAN.

Duluth, Minn.

Comparative Efficiency of Boilers

To my mind, in considering the above subject in the Feb. 13 issue, the question of efficiency may be divided into two distinct lines; one is the narrow question as to the boiler which will evaporate the most water per pound of coal, and is probably the efficiency which is most commonly used. The other is the efficiency, meaning coal cost, interest, maintenance and depreciation.

Along the first line, there is a decided difference of opinion as to these two types of boilers. Many believe that so long as the pressure is within the range of a horizontal return-tubular boiler, it is more efficient than the water-tube up to sizes where a boiler of this type can be economically built. What this size is, depends largely upon personal opinion. There seems to be no reason why boilers of this character cannot be built up to 84 in. in diameter with perfect success and carry steam pressures as high as 175 lb. Above this size and pressure, the water-tube boiler is better adapted, not because of greater efficiency but because of greater safety.

Water-tube boilers are as a rule set to accommodate the coal which may be used under them, and thus are arranged for the utmost efficiency, but this is by no means the case when horizontal return-tubular boilers are set; the location of the grate with reference to the shell is as a rule fixed and varies but little from the original settings developed many years ago. It is believed by many that this character of setting is by no means satisfactory when it comes to expecting the highest efficiency; I here refer to efficiency in the narrow sense. All of the developments and improvements in the settings—such as the lowering of certain types of patented gratebars, the installation of extra arches, and many other expedients—are for the sole purpose of removing one of the great objections to the present setting. It is done for the express purpose of thoroughly mixing the gases which may be distilled off the coal, with enough air to make them ignite properly and thoroughly burn them in the firebox. When boilers of the return-tubular type are properly set, and using good water and having good care, even higher efficiency may very often be obtained from them than from any of the water-tube type. The same condition holds true as regards thorough efficiency, meaning the cost of steam in dollars and cents.

Recently it became necessary to install a considerable increase in capacity in a power plant. The pressure required was 150 lb. By installing two 84-in. boilers, it was possible to get 596 hp. in the same space that was required for 500 hp. of water-tube boilers. It seems to be general practice also to underrate tubular boilers to a greater extent than is common with water-tube boilers.

Taking these factors into consideration, it is hard to conceive why, with moderate pressures, anyone can claim that a water-tube boiler is more efficient than a fire-tube in either the broad or narrow sense.

So far as output is concerned, there seems to be no reason why, if desired, the same amount of coal per square foot of grate surface could not be burned under a horizontal return-tubular boiler as under a water-tube. It all depends upon the draft which may be obtained, and whether the heat can be removed from the gases before they reach the stack. This relates to a question of design, and my practice leads to the opinion that it can be accomplished with the return-tubular type without involving difficulties of installation or operation. When it comes to higher pressure, the marine type of Scotch boiler has in many instances shown as high efficiency as the best types of water-tube boilers.

The water-tube boiler is only advantageously adapted to service where it has to meet very sudden fluctuations in load and where the pressures are very high. Return-tubular boilers can be built up to any pressure, but, owing to the extreme thickness of plate required, it is doubtful if they are quite as efficient and, owing to the strains to which they are subjected, they are far more dangerous under these conditions than water-tube boilers.

HENRY D. JACKSON.

Boston, Mass.

Grease for Valve Stem Bearings

Replying to G. Berna's letter in the Mar. 19 issue under the above title, I say his plan is a good one. I make a practice of using cylinder oil for lubricating the valve-stem supports and also for lubricating all other parts of a Corliss or similar valve-gearing; I believe engine oil is entirely too light to do much lubricating where it is affected by heat radiating from the steam ports and cylinder.

Engine oil smokes and burns off about as fast as it reaches the bearings, whereas if grease or cylinder oil is used on all wearing parts, it will have body enough to stand the heat and keep the bearings and rubbing surfaces well lubricated.

THOMAS BAKER.

New York City.

Low Water in a Boiler

Here is what one fireman did to a boiler under my charge. We sunk a well outside the power house and when water was reached it was necessary to keep a pump going night and day, so the contractors agreed to furnish a man to keep steam up at night in the power-house boiler.

The new man arrived and for five nights all went well. One morning when I came in I found that one of the assistant engineers had pulled the fire, as the fusible plug had blown out. The assistant said he had found the fireman excitedly walking the floor. There was about 10 lb. of steam in the boiler but no water showed anywhere in the glass and the fire was partly banked.

The fireman said that he could not get water into the boiler, but the blowoff valves showed evidences of having been opened and the blowoff tank was full of water, which proved that he had blown a large quantity of water out of

the boiler; whatever he had done, he could give no lucid account of his actions.

After the boiler had cooled sufficiently, the engineer, being satisfied that there was considerable water in it, allowed more to run in very slowly until it showed in the glass, and then he built up the fire. When there were about 20 lb. of steam, the fusible plug blew out, which showed that it had been partially melted before, it then being necessary to pull the fire. After a new plug had been put in, a water pressure of about 45 lb. was put on the boiler, at which the seams showed leaks on the under side of the drums and they had to be calked. There were no other signs of overheating or warping of the parts, and after the calking was finished steam was raised and everything seemed all right.

From the evidence it would appear that the water rose high enough to fill the gage-glass and then the fireman went to blow it down and allowed so much to run out that he was not sure whether he had any water. The feed pump and other apparatus were in perfect working condition, and in addition there was an independent supply of water under the city pressure with which he could have fed the boiler by dropping the steam to 40 lb. The valve on the feed pipe was also found closed, which showed that he was at loss to know what to do.

G. H. KIMBALL.

East Dedham, Mass.

Why Does the Pump Race?

I have had the same experience as related by W. T. Moulton in the Apr. 2 issue under the above heading. To understand the reason for the pump's actions it is necessary to take into consideration the relation between the temperature and the pressure of steam. In the open atmosphere water boils at 212 deg. F., but at a pressure of 4 lb. gage the boiling point is about 225 deg., and with his dry return the water in the receiver will probably not be much below this temperature.

When the steam pressure is shut off from the heating system, the pressure in the receiver immediately drops and ebullition of the water will take place, due to the extra heat it contains, and the pump becomes steam-bound as a result. If Mr. Moulton will insert a thermometer in the suction pipe of his pump I think he will find that the water is above 212 deg. F.

The equalizing pipe referred to is an excellent and very important feature, as it insures a steady return and constant speed of the automatic pump, and prevents any tendency of the steam to short-circuit through any part of the system. What he calls the equalizing tank is simply a pump governor, and could be eliminated by placing the float in the main receiver.

As a remedy for his trouble it is only necessary to take the precaution to close the throttle of the pump before shutting steam off the system. After a few minutes the water will cool sufficiently to pump out the receiver.

Mr. Moulton may be interested in my letter on this same subject which appeared on page 649 of the issue of Oct. 24, 1911.

E. W. CLINEHENS.

Troy, Ohio.

When the valve controlling the steam heating is closed, Mr. Moulton's pump will run all right so long as some pressure remains on the system. As soon as he opens his vacuum-breaker he relieves the pressure in the return tank and the vacuum formed in there due to the steam condensing prevents the water from running by gravity to his pump and causes it to race and pound.

If he will place a swinging check valve, open to atmosphere, in a horizontal pipe in place of his vacuum-breaker valve, the vacuum will automatically break when the pressure falls and prevent the pump from racing.

W. J. BAILEY.

Bedford, Ind.

It would seem that the receiver tank is not high enough above the pump; 4 lb. pressure in the heating system acts on the pump the same as a head of water about 9.25 ft. The pump therefore handles the hot returns as the water is forced to the suction chamber.

When the heating system is shut off, all this is changed. The pump no longer has pressure in the system to force the water to it, but only the head due to the height of the receiver tank, which is not sufficient to overcome the tension of the suction-valve springs. The pump must create a vacuum in the plunger chamber to allow the water to enter.

The boiling point of water in a vacuum is much lower than at atmospheric pressure, and as the plunger moves away to create a vacuum, the water in the clearance space of the chamber tends to break the vacuum as fast as it is created. This condition will exist until the temperature of the water in the receiver and piping has dropped considerably.

The remedy is to lower the pump or elevate the tank above its present position.

WILMER R. HERSEY.

Milford, Mass.

Joining Leather Belts

Commenting on the letter by F. S. Rise on the above subject, in the issue of Apr. 2, I have seen wire used for joining belts in a machine shop, and while it held the belts in good shape and in some respects was better than leather laces, there were some disadvantages which caused it to be discontinued. The principal reason for giving it up was because of the danger of cutting the hands in shifting the belts and in replacing those that had come off the pulleys.

The same fault can be found with most metal fasteners; while such fasteners can be used to good advantage on belts that do not have to be handled while running, I believe the old-fashioned leather lace is best for lathe belts and others that have to be shifted while in motion.

C. E. HOLLEY.

Bessemer, Mich.

Damper Regulator

Answering Mr. Smith's inquiry in the Mar. 26 issue as to the economy of using a damper regulator, my experience has been that its use has shown a marked economy.

In one plant there was a regulator, but no means of checking the results from its use. In another, the coal was weighed and a thorough account kept of all water evaporated and work done. By testing with and without the damper regulator in service, the results were easily obtainable.

These tests showed an increase of about 3 per cent. in economy when the regulator was used over that obtained when it was out of service. The steam pressure was much more uniform, too, as was shown by the recording steam gage.

The opening of the damper by the regulator is of great assistance to the fireman in maintaining a uniform furnace temperature, as when it operates to open, it is the surest indication that the fires need attention.

VICTOR JUMP.

Caledonia, Ohio.

When proper facilities and good management are used in conjunction with a damper regulator there is a decided economy in the plant operation.

In plants where there are a number of stand-by boilers connected to the line with the firing boilers, taking care of steam and load fluctuations, there may be eight or ten boilers being coaled at one time. Under such conditions it is next to impossible to maintain a uniform CO_2. When the damper opens there is an excess of air admitted, but the fires become hotter more quickly, and a uniform steam pressure is obtained. Shortly after the damper closes the CO_2 rises to a maximum, and soon the stand-by boilers are making steam.

Such conditions may be improved and a greater economy realized if each set of firing boilers is provided with a damper regulator, and each regulator set to operate at about 3 lb. greater pressure than that on the adjoining set of boilers.

Lebanon, Penn. N. AUCHENBACH.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Armstrong Shaft Governor

What is the function of the slot in the end of the lever of an Armstrong shaft governor?

L. J. I.

The slot in the end of the lever is for adjusting the regulation. For closer regulation and more sensitiveness, move the pin in the slot closer to the shaft center, to make the regulation more sluggish, to put a stop to racing, move the pin toward the rim of the wheel.

Reversal of Current

What prevented the circuit-breaker of a 60-hp. motor from tripping when the generator that supplied current to it "reversed"?

B. J. C.

Reversal occurred so quickly that the motor did not have time to slow down far enough to take sufficient accelerating current to trip the circuit-breaker.

Cutoff of a Slide Valve

On what part of the stroke should the cutoff of a slide valve occur?

H. W. C.

Usually the slide valve is designed to cut off at about five-eighths of the stroke; by adding lap to the valve, the cutoff will be earlier, but the eccentric must be advanced to give the same admission, which makes the cutoff earlier still. It is impossible to get full port opening with a cutoff earlier than half the stroke.

Feed Water Heaters

What is the heat transmission per degree difference in temperature per square foot between the steam temperature and the actual average temperature of the feed water of a feed-water heater?

W. H. C.

It depends upon the velocity of the water passing through the heater, whether the water or the steam passes through the tubes and the material of which the tube is made. A good average figure for water-tube multi-flow heaters is 250 B.t.u. per square foot per hour for plain brass or copper tubes, and 300 B.t.u. for corrugated tubes with a water velocity of 50 ft. per minute; for single-flow heaters, 175 B.t.u. for plain brass tubes with a water velocity of 12.5 ft. per minute, and for coil heaters, 300 B.t.u. for copper tubes with a water velocity of 150 ft. per minute. For steam-tube heaters with iron tubes a good average figure is 120 B.t.u.

Horsepower Required by a Motor Driven Crane

What would be the load in amperes of a 240-volt direct-current motor operating a crane and raising a load of four tons, 175 ft. in one minute; the efficiency of the motor being 85 per cent. and of the crane 65 per cent.?

D. B. A.

The work required to raise the load is

$$8000 \times 175 = 1{,}400{,}000 \ ft.\text{-}lb.$$

As the efficiency of the crane is only 65 per cent., the work required by the motor would be

$$\frac{1{,}400{,}000}{0.65} = 2{,}153{,}846 \ ft.\text{-}lb.$$

One watt is equivalent to 44.265 ft.-lb. per minute; therefore since the weight is lifted in one minute, the power expressed in watts delivered by the motor is

$$\frac{2{,}153{,}846}{44.265} = 486{,}579.9 \ watts$$

and the ampere load required by the crane would be the watts divided by the volts, or

$$\frac{48{,}692}{240} = 202.74 \ amp.$$

As the efficiency of the motor is 85 per cent., the ampere load required by the motor would be

$$\frac{202.74}{0.85} = 238.51$$

To Obtain the Temperature of the Furnace

What apparatus is necessary and what is the rule to obtain the temperature of a furnace with a metal ball?

K. C. G.

A large pail three-quarters full of water having a tight-fitting cover in which a hole is bored and a perforated tube as long as the pail is deep inserted, a metal ball and a thermometer are required.

Heat the ball to the temperature of the furnace, and before removing note the temperature of the water by the thermometer fixed in the tube. Remove the ball from the fire and quickly immerse the ball in the water, replace the cover, and note the highest reading of the thermometer. To calculate the temperature of the furnace, divide the weight of the ball, and multiply the result by the difference between the highest reading of the thermometer, and the reading before the ball was immersed; divide the product by the specific heat of the ball and add the final temperature of the water. Example: Weight of ball, 4.2 lb.; weight of water, 38 lb.; temperature of the water before immersion, 64 deg. F.; after immersion, 108 deg. F. Substituting figures, the rule would be thus expressed as a formula:

$$\left(\frac{38}{4.2} \times (108 - 64) \div 0.166\right) + 108 = 2506.7 \ deg. \ F.$$

The specific heat of cast iron at the temperature of the boiler furnace may be taken at 0.166.

Coal Required to Run an Engine

If a steam-engine plant converts 9 per cent. of the available energy in the coal into mechanical work, how many pounds of coal per hour will be required for a plant with an output of 500 hp.?

A. W. N.

The foot-pounds of work developed by the engine per hour is

$$500 \times 33{,}000 \times 60 = 990{,}000{,}000 \ ft.\text{-}lb.$$

and the heat units required would be

$$\frac{990{,}000{,}000}{778} = 1{,}272{,}493 \ B.t.u.$$

This is 9 per cent. of the heat energy which the coal must furnish. One hundred per cent., or the heat required, would be

$$\frac{1{,}272{,}493 \times 100}{9} = 14{,}138{,}811 \ B.t.u.$$

Assuming each pound of coal to contain 14,000 B.t.u., there would be

$$\frac{14{,}138{,}811}{14{,}000} = 1009.9 \ lb.$$

of coal required.

Grate Surface of Steam Boilers

Which would be the most desirable of two boilers, alike in every respect, with the exception that one has a larger grate surface than the other?

P. A. R.

With other things equal, the boiler with the larger grate surface is to be preferred. The boiler may be driven, should the occasion require, and it will give the rated capacity with a poorer grade of coal than the other. Too large a grate surface can be overcome by shortening the grate; too small a grate surface necessitates using a high-priced fuel and more frequent cleaning of fires.

Answers to Study Questions

The following are answers to the questions asked in the issue of Apr. 23:

1. Cast iron weighs 0.2604 lb. per cubic inch. The weight of the ball will be

$$64 - 3 = 61 \text{ lb.}$$

and its volume will be

$$61 \div 0.2604 = 234.25 \text{ cu.in.}$$

To find the diameter of a sphere, divide its volume by 0.5236 and extract the cube root of the quotient. Substituting figures, the rule is expressed as follows:

$$\sqrt[3]{\frac{234.25}{0.5236}} = \sqrt[3]{447.4} = 7.646 \text{ in.}$$

in diameter.

2. The heat contained in 1 lb. of steam at 90 lb. gage pressure, or 105 lb. absolute, is 1187.2 B.t.u. above 32 deg. F. The engine is capable of heating the feed water to 212 deg. F. and that amount of heat should be credited to the engine. Water at 212 deg. contains 180 deg. above 32; therefore the net heat supplied to the engine per pound of steam is

$$1187.2 - 180 = 1007.2 \text{ B.t.u.}$$

and 28 lb. of steam will deliver to the engine

$$28 \times 1007.2 = 28{,}201.6 \text{ B.t.u.}$$

A horsepower-hour is equivalent to

$$33{,}000 \times 60 = 1{,}980{,}000 \text{ ft.-lb.}$$

and an ideal engine will require per horsepower per hour

$$1{,}980{,}000 \div 778 = 2545 \text{ B.t.u.}$$

To produce 1 hp. per hour 28,201.6 B.t.u. are required. The thermal efficiency of the engine is

$$\frac{\text{B.t.u. value of hp.}}{\text{B.t.u. used by engine}} = \frac{2545}{28{,}201.6} = 0.09024 = 9.024 \text{ per cent.}$$

3. A draft is created by the difference in weight between the hot gases in the chimney and the cold air outside. The cold air, being heavier than the hot gases, will flow into the furnace and force up the column of lighter hot gases. The draft will vary according to the difference in weight between the hot gases and the cold air, which depends upon the difference in temperature between the hot gases and the entering air, and the height of the column.

4. To find the diameter of the material in an open-link chain to safely carry a given load, divide the weight to be carried by 13,350 and obtain the square root of the quotient. The constant 13,350 is good for general conditions; it varies from experiments made by different authorities from 13,440 to 13,750. Substituting figures, the rule would be expressed thus:

$$\sqrt{\frac{34{,}700}{13{,}350}} = 1.612 \text{ or } 1\tfrac{5}{8} \text{ in.}$$

diameter.

5. To determine the centrifugal force of the balls in pounds, multiply the weight of one of the balls in pounds by the square of the velocity of the ball in feet per second and divide the result by the product of 32.16 and the radius of the path described by the balls. Expresesd as a formula, it would be

$$F = \frac{Wv^2}{gr}$$

where

F = Centrifugal force in pounds;
W = Weight of the body in pounds;
v = Its velocity in feet per second;
r = Radius of the path in feet;
g = Acceleration due to gravity, or 32.16 ft. per second.

Substituting figures, the formula would be expressed as follows: 282 ft. per minute would be

$$282 \div 60 = 4.7 \text{ ft.}$$

per second.

$$\frac{12 \times 4.7^2}{32.16 \times 1.25} = 6.594 \text{ lb.}$$

Portland Regrade Operation

Eastern cities may well look to some of their Western sisters for progressive ideas in civic improvement. It is well known that Seattle, Wash., has in recent years veritably remodeled herself. From a city of steep hills she has been changed to one of gentle grades. This great project was eminently successful, largely because of the use of modern electrical and mechanical hydraulic apparatus.

Portland is now following suit by hydraulically reducing an abrupt prominence within her limits known as Goldsmith's Hill. Because of the great satisfaction given by the motors used to operate the pumps which washed the hills of Seattle into the sea, these same motors were later taken to Portland where they are now being used to drive the pumps in the regrading there.

The composition of Goldsmith's Hill is especially gravelly. The streams, therefore, are directed by large nozzles so as to undermine the lower part of the bank, and the weight of the material above brings down the sand and gravel from the working face. From here it is washed through the sluice way into Guild's Lake. In some places the height of the bank to be reduced was 140 ft.

It is expected that by the spring of 1913 the hill will be leveled and its site will be suitable for no less than 300 residences, while the operation will reclaim to the city several acres of land from Guild's Lake, half a mile away.

The motors are of Westinghouse make and rated at 650 hp., 690 r.p.m., 2300 volts, two-phase, 60 cycles, each being direct-connected to two Worthington five-stage turbine pumps. The pumping service is amplified by the addition of a booster unit consisting of a volute pump directly connected to a 900-hp. induction motor.

The pumping plant is capable of supplying 500,000 gal. of water an hour at a pressure varying between 200 and 300 lb. per square inch according to the demand. Electric energy is supplied by the Portland Railway, Light & Power Co.'s plant.

Device for Preventing Smoke

The Furnace Gas Consumer Co., of Matteawan, N. Y., has recently placed on the market a device for eliminating smoke when burning bituminous coal. Its operation involves nothing new or mysterious but, instead, it is an application of well established principles, in which connection it would perhaps be

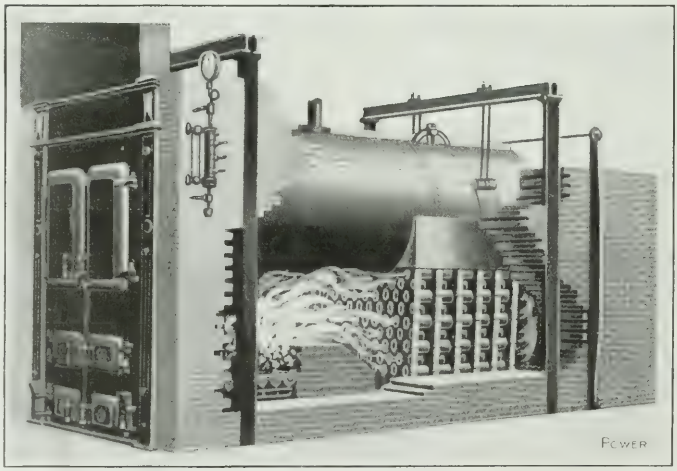


FIG. 1. DEVICE APPLIED TO RETURN-TUBULAR BOILER

more correct to designate it as a "smoke preventer" rather than a smoke consumer.

It is well understood that when bituminous coal is burned, heavy hydrocarbons are at first distilled off. In order that these may be consumed, two conditions are necessary: sufficient air must be supplied for complete combustion and a sufficiently high temperature must be maintained; cooling of the gases before the combustion is complete will result in smoke. A simple experiment will perhaps serve best to illustrate this.

Consider an ordinary kerosene lamp. When burning freely with sufficient air the flame is bright and clear, without a sign of smoke, but by gradually cutting off the supply of air the lamp will begin to smoke. Furthermore, if the chimney be removed and a cold body be introduced into the flame, smoke and soot will result. This is analogous to the hot gases in a boiler coming in contact with the colder tubes before combustion is complete. Once the distilled gases from the coal have come into contact with the comparatively cool boiler surfaces, they will not burn again unless mingled with air at a temperature sufficiently high to effect ignition.

This is just what the device under consideration is designed to accomplish. It consists of a series of refractory tubes set in the path of the gases just back of the bridge-wall, in such a manner that the gases arising from primary combustion pass through them before reaching the boiler flues. The tubes, which are 12 in. long, are placed end to end in four or five sections and are held in place without any mortar by blocks of suitable shape. The total free area through the tubes forms about 45 per cent. of the area across the furnace and is slightly greater than the area through the boiler flues. As the tubes form a continuous passage from end to end, accumulations of dust are easily blown out. Furthermore, no changes are required in the boiler setting, the device merely occupying space heretofore wasted behind the bridge-wall.

Fig. 1 shows it applied to a return-tubular boiler and Fig. 2 to a water-tube boiler having horizontal baffles. In the present form it cannot be applied to a water-tube boiler with vertical baffles.

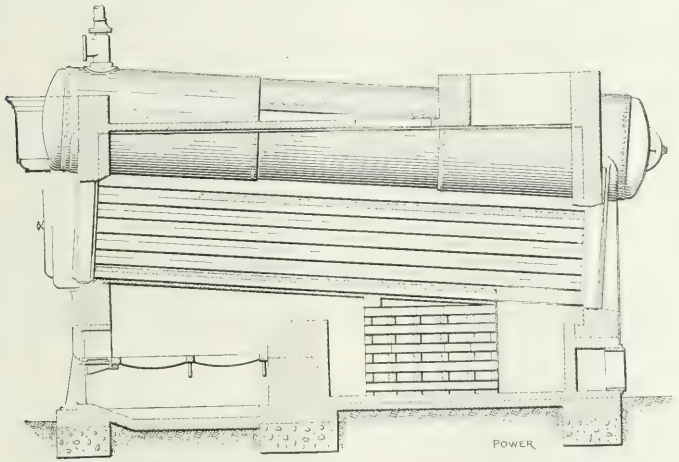


FIG. 2. DEVICE APPLIED TO WATER TUBE BOILER HAVING HORIZONTAL BAFFLES

Besides aiding in a more perfect combustion of the gases and thus eliminating smoke, the device provides a means for storing heat which helps the steaming capacity over periods of load fluctuation and also tends to keep up the steam pressure while the fires are being cleaned. During the latter operation the hot refractory tubes prevent any cold air from reaching the boiler flues.

This heat-storage value is very forcibly illustrated by the fact that when the fires are banked over night the steam gage will work up to the blowing-off point within a few hours and after being reduced about 10 lb. by the introduction of cold feed water, it will remain at about that pressure till morning.

One of these devices is installed under a 6x16-ft. return-tubular boiler at the plant of the Ellrodt-Lynch Co., of Matteawan, and has been tried out very completely. During February a series of three tests, each covering four days, were made on this boiler. Each test consisted of four runs, the first three at normal load with anthracite coal and the fourth day at maximum load with bituminous coal.

The first test was made without the smoke-preventing device installed, the second with two sections in place and the third with four sections. A very noticeable result of these comparative tests was that the loss of draft through the refractory tubes was practically the same with two and four sections installed; namely, about 0.1 in. The principal results of the tests with bituminous coal are given in the accompanying table.

Numerous observations have been made for smoke and it is claimed that only for two to three minutes at the time of firing is smoke visible.

COMPARATIVE RESULTS OF TESTS WITH BITUMINOUS COAL

	Test No. 1 Ordinary Setting	Test No. 2 Two Sections of Tubes in Place	Test No. 3 Four Sections of Tubes in Place
Heat value of fuel, B.t.u. per pound	14,310	14,210	14,610
Duration of trial, hours	11	11	11
Steam pressure, gage	105	101.7	106.2
Temperature of feed water, deg. F	32	32	32
Average temperature of gases at back of boiler	1,390	1,525	1,544
Maximum temperature of gases at back	1,600	1,790	1,800
Average temperature of gases leaving boiler	513	511	511
Maximum temperature of gases leaving boiler	565	545	545
Draft in uptake inches	0.4	0.5	0.45
Draft at back of boiler, inches	0.3	0.35	0.2
Draft over fire, inches	0.3	0.25	0.1
Boiler horsepower developed	178.1	181.3	191.1
Equivalent evaporation from and at 212 deg. per pound of dry coal, pounds*	9.63	10.04	10.41

*Uncorrected for quality.

Bill to Regulate Hydro-electric Developments

A bill to regulate the development of hydro-electric power in American navigable waterways was recently introduced in Congress under which those desiring to construct or operate plants must first obtain Government sanction.

It is proposed that an annual rental of $1 per horsepower developed be paid to the Government, this rate to be subject to readjustment every 10 years. If, however, a disagreement arises over this rate, that for the next 10-year period shall be double that of the preceding period; a reasonable rate will then be fixed by the courts.

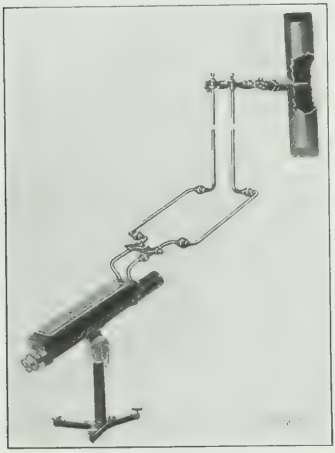
This bill would also permit the Secretary of War, when authorized by Congress, to purchase the buildings and equipment of the grantee at the expiration of the term for which the permit was issued. No permit would be issued for a longer period than 50 years.

Portable Induction Meter

Several types of G. E. flow meters have been described in these columns (see page 1015, June 27, and page 154, Jan. 25, 1911, issues). The type F W-2 meter operates with the same design of pilot tube that is used with the types R W-2 and F W-2 meters previously described.

The meter, illustrated herewith, is a portable indicating instrument giving instantaneous values of the rate of flow in gallons per minute. It can be adopted by the operator to measure the flow in pipes of any diameter at any temperature within its range. On account of its simplicity, light weight and flexibility, it is especially useful for general testing work, locating leaks, etc.

The meter consists of a U-tube with glass legs, which are filled for part of their height with mercury. Located centrally with respect to the glass tube is a cylindrical chart from which is read the rate of flow in gallons per minute. Suitable auxiliary scales are provided so that the indication is correct at any condition of temperature and for pipes of various diameters within the range of the meter.



INDICATING FLOW METER

The U-tube system can be inclined from a vertical to a nearly horizontal position by revolving it about its point of support. If the velocity of the water is high, the meter may be set in the vertical position; if, on the other hand, the velocity is low it may be inclined toward the horizontal. In this manner the meter can be readily adjusted to accurately measure very high or very low velocities.

The adjustments of the meter for the proper pipe diameter and temperature of the water at the point where the nozzle plug is installed are made by rotating the graduated scales at the lower end of the meter. The two sights are set to coincide with the meniscuses of the mercury in the glass U-tube. The indication of the pointer on the chart multiplied by a constant depending upon the inclination of the meter from the vertical and by the area of the pipe in square inches will give the total rate of flow in gallons per minute.

The meter may be used to measure the flow under normal conditions in any number of different pipe lines if they are more than 2 in. in diameter. It is only necessary to provide the pipe with a nozzle plug of the proper length to which plug the meter can be connected.

The meter is calibrated to read in gallons per minute at 39.1 deg. F. This instrument is manufactured by the General Electric Co., Schenectady, N. Y.

Non-Leaking Damper Frame

Owing to the fact that a good deal of latitude must be given to expansion and contraction, there can be no such thing as a close mechanical fit between the damper and the damper frame of a steam boiler. One source of appreciable loss is the leakage of cold air from the outside through the crevices surrounding the damper plate. This is a most difficult matter to deal with successfully.

A simple device, however, has been in use for some time, particularly in the Manchester district in England, where problems of economy are closely studied in the large cotton-mill power plants, which appears to afford a satisfactory solution. It is made by the Courts-Turner Engineering Co., of Manchester, and is shown in Fig. 1. It will be seen that the damper frame consists of a combination of three castings the bottom one of which, *A*, is an oblong frame with a flange cast all around the top. The lower part of this casting is let into the brickwork surrounding the damper to a depth of 2½ in., so that the flange rests on the top of the brickwork and is grouted in with cement. The upper or horizontal face of the flange has a groove cast in it all the way around, and into this groove ordinary asbestos packing is inserted.

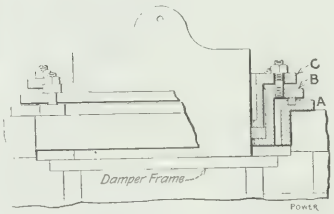


FIG. 1. CONSTRUCTION OF NON-LEAKING DAMPER

The second casting, *B*, is somewhat similar in form to the first one, and also has a flange at the top which when placed into position rests on the asbestos packing, and in this way forms with *A* an air-tight joint. There is no rigid mechanical connection between *A* and *B* and there is sufficient clearance to allow the latter to move both lengthwise and sidewise to the boiler so that it can adjust itself to the damper. This casting also forms a stuffing-box in which a length of woven asbestos packing is placed which entirely surrounds the damper. Four lugs attached to bolts passing through the frame *A* and fixed in the brickwork of the boiler setting keep the second casting from rising with the damper when it is worked.

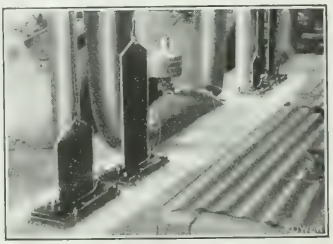


FIG. 2. AN INSTALLATION OF NON-LEAKING DAMPERS

The third casting, *C*, is similar to an ordinary gland, and brings a slight pressure to bear on the packing surrounding the damper so as to make the joint air-tight. The damper can be moved up or down quite freely and there is no fear of its binding in any way. The wear on the asbestos packing in the gland is insignificant, and therefore the leakage of air from the outside of the boiler setting to the flues past the edges of the damper is avoided.

Fig. 2 shows an installation of these dampers. It is not possible to give any data as to the possibilities of the saving to be effected as the results vary in accordance with the boilers to which the device is applied. Where economizers are employed, however, its installation should be well worth while as it helps to keep up the temperature of the entering gases and this means just so much more heat recovered from the waste gases

Revolution Counter and Stop Watch

The instrument shown herewith consists of a revolution counter and precision nonmagnetic stop watch. The two instruments are so connected that they will simultaneously start to work the moment a slight pressure is applied to the center spindle. As soon as the pressure is released both the counter and watch will stop at the same time, thus

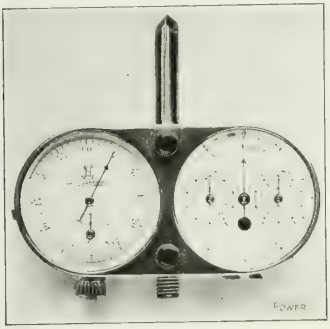
indicating on the dials the number of revolutions made by the object under test in the time elapsed.

The instrument is especially recommended for high numbers of revolutions and it can be used for any rotating shaft or spindle up to 30,000 r.p.m.

The duration of the test is indicated in minutes, seconds and fractions thereof; the small pointer on the watch dial records up to 30 min. and then repeats.

The revolution counter has three pointers which indicate from 1 to 100, 100 to 1000 and 1000 to 10,000 r.p.m., respectively.

A short test lasting 6 sec., multiplied by 10, is sufficient to measure the speed of any machine.



Revolution Counter and Stop Watch

The instrument is equally useful for right- or left-hand revolutions. It can be applied to the shaft to be tested without previous knowledge of the direction of rotation. No adjusting or setting is required. The appearance of either a red or a black disk on the counter dial (shown as a black spot on the dial) indicates whether right or left rotations are being counted.

The dial figures, which correspond in color to the disk, are used in the reading. The counter as well as the stop watch can be instantly set back to zero.

The instrument is strong and has a fine grade movement. It is manufactured by Schuchardt & Schütte, 90 West St., New York City.

Boiler Connections

By Everard Brown

In a boiler house the question of safety should come first, and all supports, pipe lines, connections, etc., should be so designed and constructed that an ample factor of safety will exist. It is possible in most all cases to so locate the steam headers, valves and piping and arrange the various connections that the whole equipment will present an appearance which will at once dissipate any fear for personal safety, for it usually follows that if proper care and attention have been given to these things one can rest assured that the whole installation has been made in a similar manner.

As is well known, there are three important factors to be considered in connecting up a boiler; namely, all connections must be of sufficient strength (with some in reserve) to withstand the internal pressure; they should be so located that no undue strains will result from expansion or contraction; and adequate drainage should be provided.

To insure the utmost safety, all pipe connections to the boiler shell, unless they are not over, say, 1 in. in diameter, should be made by means of pressed or rolled steel flanges or carefully annealed steel castings riveted to the plates. For connections 12 in. or larger, even the steel castings are being replaced to a large extent by the pressed or forged flanges. The smaller connections are usually made by tapping holes and screwing the pipe into the shell.

Under no circumstances is it advisable to use cast iron. The steam header should be placed at a sufficient distance from the nozzle of the boiler to permit the use of a gooseneck connection having a large enough radius to be capable of considerable expansion without bringing about dangerous strains on the flange connections or the nozzle. This gooseneck should be vertical and should be connected to the top of the steam header. If local conditions make this impossible, a connection on the side of the header may be made but in all cases a bottom connection should be avoided.

A stop valve, preferably of the gate type, with an outside screw and yoke, is usually located in the gooseneck as close to the steam header as possible and a nonreturn valve of the triple-acting type should also be set in the gooseneck but close to the boiler nozzle. Under usual operating conditions it is seldom necessary to operate the stop valve and it need be closed only when someone is inside the boiler so that there will be a double protection against steam coming over from the other boilers.

The nonreturn valve will automatically connect the boiler with the steam header as soon as the required pressure has been reached and when taking off a boiler this valve should be tripped by hand. In this way the valve is tested at certain intervals, thus precluding any danger of its becoming inoperative without the knowledge of the attendant.

In order to prevent any pocketing of water when the valve is closed, it is well to connect a drain pipe to each gooseneck at the proper place. These drain pipes should lead to receivers or traps which will automatically remove the collected water. Sometimes a check valve is put in these drain pipes to prevent any backward flow of steam when the boiler is out of service.

Brooklyn Fire Bursts Boiler

A stubborn fire under iron cover on a long pier at the foot of Pacific St., Brooklyn, practically wrecked the Dow's Stores six-story grain elevator on Apr. 21.

Three fireboats made little impression until a boiler explosion in the elevator tore holes in its side and floor and gave them access. The flight of iron and timber caused the fireboats to back away several times. A laborer was injured.

Chicago Boiler Explosion Maims Several

By the explosion of a boiler in a five-story brick building at 9 Michigan St., Chicago, on Apr. 15, several persons were injured; one, the fireman, may die. About 150 workmen in the building rushed in a panic to the street, and a telephone operator on the first floor was thrown from her chair.

The explosion, according to the daily press, wrecked the boiler-room and set fire to the upper floors, which required a general alarm before it was extinguished. No reason is given for the accident.

Two Boiler Explosions in Pennsylvania

On Apr. 17, two boiler explosions were reported to have occurred in Pennsylvania, one in an oil-well plant, at Canonsburg, in which a man was perhaps fatally injured. No cause is given in the press report.

The other explosion happened at the fertilizer plant at Seven-Stars, near Pottsville. The shell went straight up to the roof and narrowly missed several workmen standing near by. One man was injured and is in a critical condition. The cause is unknown.

Boiler and Flywheel Accidents

According to the April bulletin of the Fidelity & Casualty Co., from Feb. 10 to Mar. 7 there were 25 boiler explosions, and from Feb. 12 to Mar. 18, six flywheel explosions.

There were 15 persons killed and 26 injured by the boiler explosions. In the flywheel accidents three persons were killed and two were injured.

Middlesboro Plant Wrecked by Boiler Explosion

Press dispatches state that two men were killed and several others seriously injured on Apr. 19 when the boiler in the lumber-milling plant of the Powell's River Co., near Middlesboro, Ky., exploded. The force of the explosion was sufficient to wreck the entire plant. The cause is given as low water in the boiler.

"Titanic's" Rescued Firemen

As was to be expected, the boiler-room crew of the "Titanic" had its full share of suffering and death.

The 29 boilers and 159 furnaces demanded a force of about 180 men; 13 of the survivors are shown in the accompanying engraving. Every means were taken to provide them with money and clothing, and send them home or get them places on other ships if they desired, only a few men having been detained to give evidence before the Senate Investigating Committee.

"Titanic's" Firemen Survivors

Many acts of bravery and heroic sacrifice were related by the surviving firemen. Thomas Andrews, the designer and Harland & Wolff's representative; Mr. Cummings, the builder of the engines, and ten supervising engineers who stood by to watch the engines' maiden performance, refused to leave the ship and rendered great assistance to the women and children in getting them into the boats.

James Thompson, a fireman who is in a New York hospital recovering from his injuries, declares that he knew the "Titanic" was running at 77 revolutions (22 knots) on Saturday, and that this speed was increased on Sunday to nearly 23 knots, which was maintained up to the time she struck the iceberg. It has never been disputed that the "Titanic" was not under full speed when she struck. Thompson further said that after three days he "hardly saw anything else but the 215 lb. on the gages as the engineers were driving the firemen to do their utmost."

Most of the men did not leave the boiler rooms until the incoming water forced them out. Some of these men were afterward picked up in the open sea, into which they had jumped a few minutes before the "Titanic" went down.

It is through the courtesy of the evening edition of the *New-Yorker Staats-Zeitung* that we are enabled to give the picture of these rescued firemen.

SOCIETY NOTES

Rudolph Diesel, D. E., D.Sc., director of the Verein Deutscher Ingenieure and the inventor of the Diesel engine, was made, on Apr. 30, an honorary member of the American Society of Mechanical Engineers, in the auditorium of the Engineering Societies Building, New York City. During the evening, under the auspices of the Gas Power Section, Dr. Diesel delivered an illustrated lecture on "The Development of the Diesel Engine."

Dr. Rudolph Diesel

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Dr. Diesel, it will be recalled, recently came to this country to investigate the progress which is being made here with oil fuel and on business connected with the Busch-Sulzer Bros. Diesel Engine Co., St. Louis, Mo., of which he is a director. The doctor has expressed himself as of the belief that America is destined to lead the world in the development of oil-fuel motive power.

Our issue of May 7 will contain a full account of his paper.

Lexington, Ky., is to have a stationary engineers' association. It will represent the engineers of central Kentucky, including those in Lexington, Georgetown, Paris, Nicholasville and Versailles. The first meeting, in which plans were discussed, was held in Lexington on Apr. 9. Officers will be elected shortly.

Marine Engineering Publications Consolidated

The Aldrich Publishing Co., with a capital stock of $100,000, all paid in, has been organized under New York laws to take over under one management the engineering publications of Herbert L. Aldrich, which have hitherto been separate organizations.

These include *International Marine Engineering*, which he founded 15 years ago in the interests of shipbuilding, also a publication of the same name which he established in London, England, in 1906. Another publication is *The Boiler Maker*, covering the design and construction of steam boilers for locomotives, steamships and all other uses. Besides these magazines Mr. Aldrich publishes several tech-

nical books devoted to engineering subjects of interest in the industries covered by the magazines.

The head offices of the new company will continue as heretofore in the Whitehall Building, 17 Battery Place, New York City.

OBITUARY

Benjamin Guggenheim

The first definite information received of the death of Benjamin Guggenheim, whose life was lost in the going down of the ill-fated "Titanic" on Apr. 14, was received by his widow in a message from Mr. Guggenheim, delivered by an assistant steward who was with him until a few minutes before the "Titanic" sank. The message was: "If anything should happen to me, tell my wife in New York that I've done my best in doing my duty." In these words lies the keynote of Benjamin Guggenheim's whole life.

Born on Oct. 26, 1865, the fifth of the seven sons of Meyer Guggenheim, the founder of the great firm having mining interests all over the world, young Benjamin, at 20, took charge of the company's mining properties in Leadville, Colo., and to his shrewdness and energy is largely due the concern's success in after years. Later, he came East and managed a plant at Perth Amboy, N. J.

In 1903, Mr. Guggenheim erected a large machinery plant in Milwaukee, Wis., which was later merged in the International Steam Pump Co., of which he was elected president in 1909. With his brothers, he was also the controlling factor in the American Smelting & Refining Co.

Today, the International Steam Pump Co.'s products are limited only by the confines of industry in this country and abroad. It has seven plants, each large in itself, which operate in the United States, and one in England, at Simpson. The company employs 10,000 men.

Mr. Guggenheim married Miss Floretta Seligman, a daughter of James Seligman, the banker, who survives him with three daughters.

Benjamin Guggenheim

Copyright, 1912, Marceau, N. Y.

PERSONAL

James O. Westberg, formerly chief engineer of the isolated plant at Feltman's, Coney Island, has accepted a position as erecting engineer with the Shipley Construction & Supply Co., the New York representative of the York Manufacturing Co., York, Penn., builders of ice-making and refrigerating machinery. Mr. Westberg is a member of the Modern Science Club, the N. A. S. E., and was the founder and first president of the Combined Engineers, Brooklyn, N. Y.

Examinations for Inspection Service at Chicago

The Illinois Civil Service Commission announces that an examination will be held in Chicago on May 17 to fill present and future vacancies in the department of factory inspection in each of the following branches:

Electrical: Applicant must have practical knowledge of electrical generating apparatus and of the methods used in wiring and installation.

Ventilation: Must have both technical and practical training in ventilation and sanitation, understand the occupational disease law, and be able to locate and analyze industrial poisons.

Mechanical: Must be especially experienced in shop work and be able to detect infringements of laws governing the protection of workmen about machinery.

These positions pay $100 per month and all necessary traveling expenses; the age is limited between 25 and 50 years.

Copies of the laws may be had by writing to the State Factory Inspection Department, Security Building, Chicago. W. R. Robinson, of the Civil Service Commission, Springfield, Ill., will furnish application blanks. The aplication must be filed with the commission at Springfield prior to 9 a.m., May 10.

Doubtful Economy

Hans Schmidt, proprietor of a western Minnesota sawmill, used for fuel the sawdust from the factory. It cost him nothing, but it kept four men busy shoveling it. Recently he was persuaded to put in a new equipment which would reduce the amount of fuel one-half.

After the machinery had been installed, the agent called, expecting to be congratulated. But the German eyed him gloomily.

"Doesn't the new plant do all I claimed?" he asked.

"Yah; but I oberlooks sometings," replied Hans.

"What was that?"

"Vell, it dakes only dwo mens to handle de fuel, but it dakes de udder dwo mens to haul away what we don't use und a team besides."—*Hampton's Magazine.*

Moments with the Ad. Editor

If good advertising is anything it is informative and helpful.

We have heard some people make caustic remarks about the quantity of advertising in a technical paper and we remember hearing a publisher of a trade paper wax hysterical over putting an advertisement on the front cover. He thought that the front cover should be devoid of advertising and would substitute a pretty picture for a well written and well displayed advertisement.

Any wise engineer can get more out of a good ad. than he can out of the best painting the world ever saw—and the average front cover "picture" is far from that.

Here, in any event, is what E. S. Wylde, of Pinerolo, Italy, thinks about ads. and especially the value of POWER'S advertising to its foreign readers:

There are just one or two things I should like to mention and which I thought might interest readers of POWER. On page 416 of your issue of March 19th you say: POWER never makes much of a "holler" about its foreign circulation, but it's "there," etc. Well, I don't know about the "holler," but I do know about its being there, all the same, so I thought perhaps a little personal experience might show some of your readers what those on the outskirts, as it were, of your circulation think about and how they make use of "Moments With the Ad. Editor" and the Ad. section of POWER.

I started to take POWER some four or five years ago when stationed in Mexico, and from the very first it both interested and instructed me, but it was only when I came here some three years ago and found myself up against some tough propositions that I decided to test for myself some of the many ads. that seemed to fit my case. Well, firstly the system of lubrication in the mill was both wasteful and inefficient under the old system of oiling, so I decided to try what Albany Grease would do, and I am pleased to say that it turned out A-1. and now we have no more oil dropping about and no trouble with hot bearings, and one man looks after all the mill in place of three employed formerly. Then again we had trouble with the separator on one of our engines of 200 hp. on account of the face of the bottom flange having several blow holes in it, which made it very difficult indeed to keep a tight joint, so I decided to see what "Smooth-On Cement" would do. I obtained a tin and after having had the joint carefully cleaned I applied the cement according to instructions and found I had a tight joint and I have not had to have it touched since, and that is eighteen months ago. Thirdly, we have several belt drives in the mill which are subjected to very severe service. They are fast-running belts with very short centers and small arcs of contact, which caused them to slip a good deal, particularly on Monday mornings, after the machinery had become cold and stiff by standing over Sunday. So I wrote for a can of "Cling Surface" and again the ad. made good and we have had no further trouble with those belts, and that is over a year ago. When one considers what a very heavy freight charge we have here I think it may be fairly said that POWER ads. "make good." And lastly it was in the Ad. section of POWER that I first saw about the International Correspondence Schools and convinced myself that it was a good thing, so I joined the Steam Electric course and have and am deriving both pleasure and profit out of it, and have been able to give our engineer some tips that have proved to be to our mutual benefit. It has also enabled me to appreciate more fully the various articles appearing in POWER.

So you see, Mr. Editor, even if it is not making a great deal of noise about it, POWER is doing a good work, and its ads. are making good in perhaps very many places outside the United States. I rather think if you were to invite some letters from these friends of yours abroad you would find them mighty interesting reading if nothing else.

Wishing you and your paper every success.

When the Selling Section brings real help to a man located far from the source of supply, it has proved itself worth while.

By the same token, those of its readers who are close to "headquarters," to whom freight charges are no handicap, can well profit by reading the ads. and buying advertised goods.

POWER

Vol. 35 NEW YORK, MAY 7, 1912 No. 19

"Engineers All Dead"

THIS sentence was a part of the official report sent to the White Star Company in England regarding the recent "Titanic" disaster.

No mention of brave acts, of heroic rescues or of fidelity to duty, just "Engineers All Dead."

The "Titanic" carried a regular engine-room force of 34; with the stokers, coal passers and trimmers, a total of approximately 290 men. Not an engineer was saved, and with the exception of a few firemen, all of these are dead.

Two-thirds of these men were off duty when the ship struck the iceberg. They at least had a fighting chance, but the rules governing their actions were, in case of accident every man to his post.

Not on deck where there was a chance to cling to floating wreckage, but down in the ship's bottom, 122 ft. below the boat's deck. Not to stations where the gradual settling of the hull in the icy water could be seen, but down below where the desperate nature of the damage to the ship was evident.

Down where they could note the rapidly rising water, the failure of the pumps to keep it down, and know with a certainty that the ship was doomed.

But for these men the lights of the "Titanic" would not have glowed until shortly before she sank; but for the lights a panic among the passengers would have occurred, with a still greater appalling loss of life.

These engineers were not deceived. They knew that when they had done their duty, death awaited them. And they performed that duty; we know it, for the dispatch "Engineers All Dead" is conclusive evidence.

Marine engineers have scant chance of being saved when large ships are wrecked, for duty demands that they stay at their station. No chance to escape in charge of a ship's boat loaded with passengers, no opportunity to hear the order, "every man for himself." They stand by obeying signals until it is too late to gain the deck, and then they die like men—heroes every one.

Two hours is an eternity under such circumstances as surrounded the sinking of the "Titanic." Within ten minutes after the ice tore through the ship's side, these men knew that they were doomed. They had two hours to decide whether they would die doing their duty, or whether they would attempt to escape in one of the few life boats.

They chose to die. No excuses are being made by them as to how they were saved.

It is hard to die in the light, but more so in the dark interior of a sinking ship, where the bubbling of the inrushing water sounds the funeral dirge.

Carnage? Yes, and then some. Love of life and family would almost drag them away from their post, but fidelity to duty was the stronger, and won the battle.

And when they had done all that humans could do, had kept the lights bright and the pumps going until the fatal plunge, they clasped hands in a last farewell and went down with their ship.

We pay tribute to the heroism of these engineers who died that others might live, and, when the Recording Angel squares accounts, what more fitting entry could be written, regardless of creed or belief, than the significant words, "Engineers All Dead"?

Power Plant Recording System

By L. R. W. Allison

Forms used in making requisition for material and routine employed to keep complete and accurate record of all material issued.

Manner of indexing material received, on hand and issued.

Manner of recording information concerning motor and meter installations, etc.

The value of a system for recording, together with the printed forms and mode of procedure, whether employed for material, costs, kilowatts, revenue or the miscellanea connected with the lighting and power business, lies in its ability to render positive service at minimum expense and indirectly netting pecuniary value in its performance.

There are in use almost countless dispositions for registering stock and material required, purchased and supplied, with which the engineer is expressly interested for continuous operation. From the verbal orders of the operator in the small isolated plant to the formal printed blanks of a public-utility company whose plants may be located at distances from a main center, there are many methods which are essentially wanting in actual value.

No competent requisition or store system has been devised in a day and neither has it been a product of but one mind. It is perfected by a gradual growth; it is the result of experiments and trials of collective association, and is founded upon the demands of the plant in harmony with the office establishment.

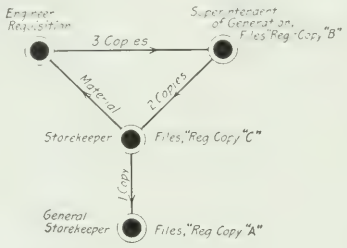
In power-plant work the system must necessarily fit the conditions of the business; it must offer accurate and prompt service to the engineer and at the same time protect the company from all needless expense.

Within a score of years, the Pacific Light and Power Company, of Los Angeles, Cal., has grown to such proportions as to affect generating plants from Borel, on Kern river, to Redondo beach, and serve territory in Los Angeles and San Bernardino counties with energy for lighting and power. With this augmentation has come the need for a store and supply system entirely within the jurisdiction of the main offices. The accompanying features of the process employed have been in satisfactory use for some time and have served all departments. Only the power-plant end will be considered here.

Requisitions for Material in Stock

Requisition books containing the form shown in Fig. 1 are supplied to the chief engineer and chief operator in charge at each of the various stations. Each requisition is numbered as shown, and is in triplicate, a blue, white and yellow sheet, lettered A, B and C respectively, one original and two carbon copies.

Space is provided for notation in the upper right corner for the designation of the job for which the material is required, as follows: "superintendent's order number," for such work ordered by the superintendent of generation, who has direct charge of all steam and hydraulic plants; "estimate number," for such special construction work as has been estimated in cost and approved by the general manager; "standing-order number," for regular maintenance and repair work, each class being segregated for the particular station and a number given, as "maintenance of generators and exciters, 5365," "maintenance of steam engines,



F'G. 2

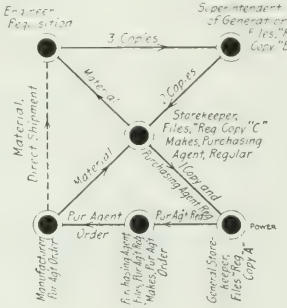


FIG. 3

PACIFIC LIGHT & POWER CO. Date

No 25021

REQUISITION ON STOREKEEPER

STOREKEEPER:—Please ship to

A Care of

Destination

SHIP BY

Supt. Order No.

Estimate No.

Standing Order No.

Account

QUANTITY	ARTICLE	QUANTITY	PRICE	AMOUNT	CLASS

This material to be used for

Approved —

Superintendent

Foreman

REQUISITION FILLED

Date

By

FIG. 1. REQUISITION FOR MATERIAL IN STOCK

E. M. LATHAM

PURCHASING AGENT

654 PACIFIC ELECTRIC BUILDING

LOS ANGELES, CAL.

ORDER NO.

REQN. NO

Please supply the following material for the use of this company. Ship to

Ship by

PLEASE SEND ALL SHIPPING NOTICES IN DUPLICATE TO CHIEF OF STORES, 633 PACIFIC ELECTRIC BLDG., LOS ANGELES, CAL.

PLEASE SEND TRIPLICATE COPIES OF INVOICE SHOWING OUR ORDER AND REQUISITION NUMBERS TO 624 PACIFIC ELECTRIC BLDG., LOS ANGELES.

ATTACHED ACKNOWLEDGMENT MUST BE PROPERLY FILLED IN SIGNED AND RETURNED

PACIFIC LIGHT & POWER CORPORATION

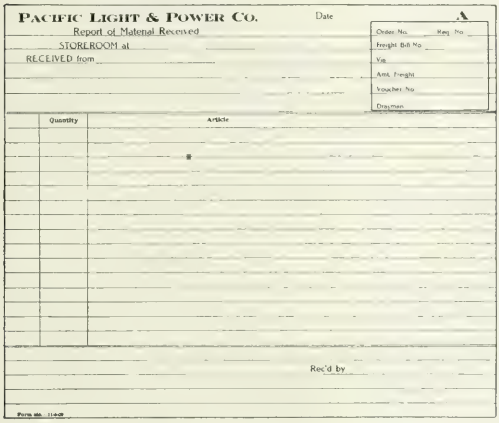
BY

PURCHASING AGENT

FIG. 4. PURCHASING AGENT'S ORDER

5379," and the like. The "account" line is for recording purposes at headquarters.

Each item of material needed, with its quantity and what it is to be used for, together with necessary shipping directions, is listed in the sections provided. The columns at the right, marked "quantity," "price," etc., are for the use of the storekeeper. All requisitions must bear the signature of the engineer or operator in charge on the line designated "foreman" and must be approved by the superintendent. The disposition of the proved by the superintendent, it follows the routine noted in Fig. 3. In this instance, the storekeeper, retaining copy C, as before, relists the material on a "purchasing-agent's requisition," this being identical with the form in Fig. 1 except for the omission of the five vertical columns at the right and the accompanying notations; it is likewise in triplicate.


PACIFIC LIGHT & POWER CO.

Date

A

Report of Material Received

STOREROOM at

RECEIVED from

Order No. Req. No.

Freight Bill No.

Via

Amt. Freight

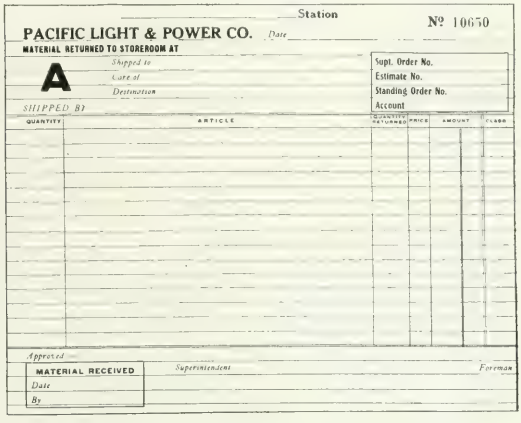
Voucher No.

Drayman

Quantity | Article

Rec'd by

Fig. 5. "Material Received" Blank


Station

PACIFIC LIGHT & POWER CO. Date

№ 10650

MATERIAL RETURNED TO STOREROOM AT

A

Shipped to

Care of

Destination

SHIPPED BY

Supt. Order No.

Estimate No.

Standing Order No.

Account

QUANTITY | ARTICLE | QUANTITY RETURNED | PRICE | AMOUNT | CLASS

Approved

MATERIAL RECEIVED

Date

By

Superintendent

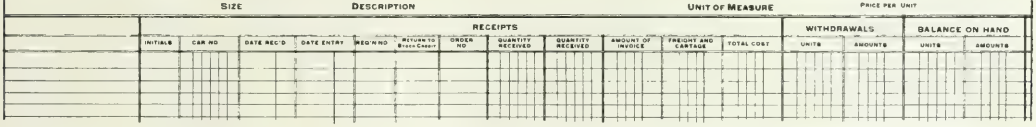
Foreman

Fig. 6. Blank for Material Returned to Storeroom

The purchasing agent's order, Fig. 4, is issued to the manufacturer with the original requisition number and an order number to afford record for the invoice. This is made out in duplicate to the recipient of the order, one copy to be returned to the purchasing agent as acceptance for the material specified. Additional copies are made, of individual colors, for the general manager, general storekeeper, storekeeper, superintendent and the engineer who signed the requisition.

Report for Material Received by Engineer

When material is received by the engineer in charge directly from the dealer without passing through the storeroom, as where direct shipment is made to a station at an isolated point from the main office, the "material received" blank, shown in Fig. 5, is employed. This is made out in quadruplicate, notated as A, B, C and D, in pink, yellow, white and blue respectively. The engineer, retaining the C copy, forwards the additional three to the superintendent, which, being approved by him, are distributed to the storekeeper, chief storekeeper and price clerk. This serves to protect the engineer and affords the company an absolute check on expenses for material so received, as no remittance is made for the invoice until a report from the operator is on record


P. L. & P. CO.

PACIFIC LIGHT AND POWER COMPANY

STOCK LEDGER

Sheet No ...

Invoice

Articles

Classification No.

Price per Unit

Size

Description

Unit of Measure

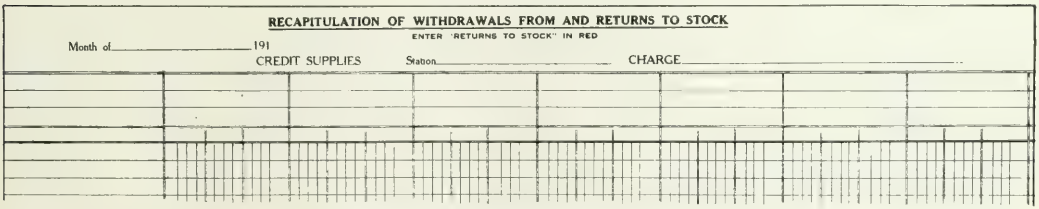
Price per Unit

Price per Unit

Receipts | Withdrawals | Balance on Hand

Initials | Car No. | Date Rec'd | Date Entry | Req'n No. | Return to Store Check | Order No. | Quantity Received | Quantity Received | Amount of Invoice | Freight and Cartage | Total Cost | Units | Amounts | Units | Amounts

Fig. 7. Loose-leaf Ledger Record of Stock


RECAPITULATION OF WITHDRAWALS FROM AND RETURNS TO STOCK

ENTER "RETURNS TO STOCK" IN RED

Month of 191

CREDIT SUPPLIES Station CHARGE

Fig. 8. Blank for Recording Recapitulation of Stock

three requisition copies, and the supply of material, takes a course as shown in Fig. 2.

Requisitions for Material to Be Purchased

When special material is to be purchased, the requisition is additionally marked, if necessary, with the type of manufacture desired. After being ap-

and found to tally therewith. A "call for the receipt of goods" is issued by the price clerk to the engineer in charge, passing by way of the superintendent when this report is not received in due time.

Material Returned to Storeroom

For such material as may be received from the storeroom by the engineer and not placed in service, provision is made for its formal return and the proper credit is given by use of the form in

Fig. 9. Transformer Installation

Fig. 6. This is issued in triplicate by the engineer, one copy being retained for his record, the others, after approval by the superintendent, going to the storekeeper and the general storekeeper as in the case of the requisition for stock articles.

The various colors assist in definite disposal as each has its respective department for filing, with the purpose of such, whether for material desired, material returned, etc., easily noted.

Records of Stock

Records of stock on hand, additions to, withdrawals from, etc., are made in a

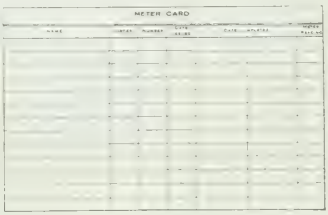


Fig. 11*a*. Meter Card

loose-leaf ledger, with 10¼x16-inch sheets, and ruled as in Fig. 7. Recapitulation of stock is recorded on an 8½x14¾-inch form, Fig. 8, all "returns to stock" being noted in red for quick reference. These forms give the company an accurate record of stock disposition and stock on hand at minimum labor.

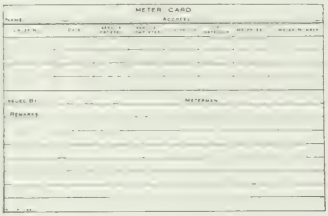


Fig. 11*b*. Reverse Side

Transformer and Motor Installation

A record of transformers installed or removed is made on the cards shown in Fig. 9; these are of light-weight 4¾x8-inch stock. Consumers supplied, the capacity and load on the transformer, together with other information as will be noted, are kept on file.

For motor installation, both sides of a 4½x9¾-inch card in the form given in Fig. 10 are employed. The record is complete, from the consumer, location and purpose for which used, to test the data and the equipment installed for proper connection. These cards are especially valuable for reference when trouble is manifested in operation long after the date of installation.

Meter Records

The form shown in Fig. 11, printed on a 4x6-inch card, is for recording data connected with the installation of meters for consumers. The card, Fig. 12, gives on one side information regarding the circuit, the meter and the meter load, and on the reverse side a record of incandescent- or tungsten-lamp renewals. This form is 5x8 inches in size.

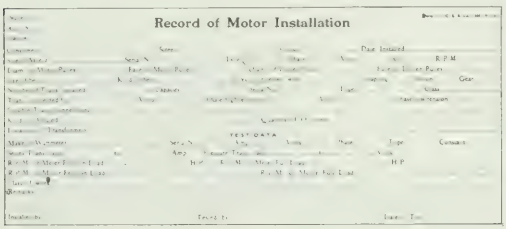


Fig. 10*a*. Front of Motor Installation Record Card

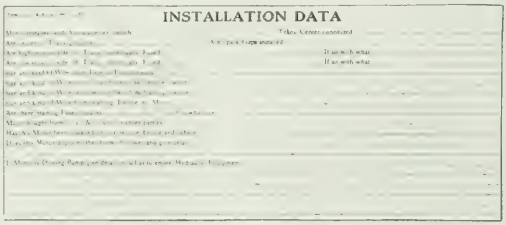


Fig. 10*b*. Installation Data on Back of Card

Material Returned by Storeroom

Material placed in the storeroom or held in reserve by the storekeeper for a particular station through special circumstances and later delivered to the engineer, is cared for by means of a blank practically identical with the form shown in Fig. 6 and designated "material returned by storeroom to foreman." Three copies are prepared and pass in the routine as indicated.

All forms are uniformly 7½x8½ inches.

All cards for transformer, motor and

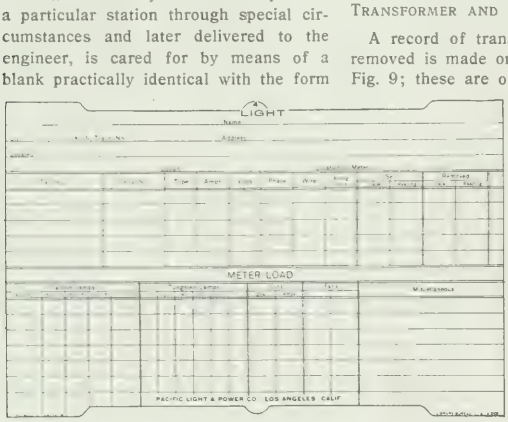


Fig. 12*a*. Information on Circuits, Meters and Meter Load

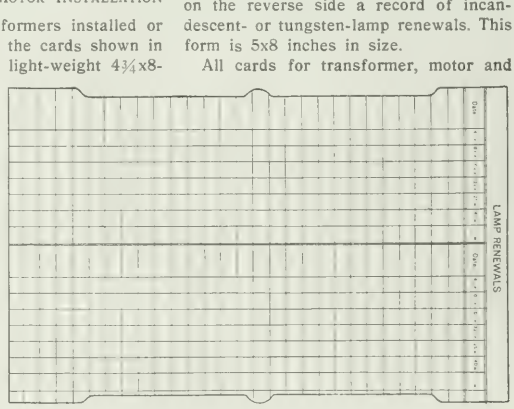


Fig. 12*b*. Lamp Renewals

meter installations and operating data are filed vertically in cabinet drawers in card-index style. They are arranged alphabetically, according to name or location, as conditions warrant.

A Heavy Blooming-Mill Engine

By Edward T. Child

Description of an exceptionally heavy angle-compound Corliss engine which drives the blooming-mill at the plant of the Pittsburgh Steel Co.

This engine frequently develops more than 7000 hp.

The engines driving the blooming and billet mills of the Pittsburgh Steel Co., at Monessen, Penn., exhibit a number of interesting features.

The engine room is a separate building completely cut off from the mill by a steel and glass partition, and is thus kept as clean as any electric station. The several mills are driven by spindles reaching through the partition. The blooming mill weighs 4,000,000 lb. and was built by the Mackintosh & Hemphill Co., of Pittsburg. It reduces 24x24-in. ingots to 6⅞x6⅞-in. blooms in nine passes through the rolls. This mill is driven by a 48 and 84 by 60-in. angle-compound Corliss engine, built by the Southwark Foundry & Machine Co.

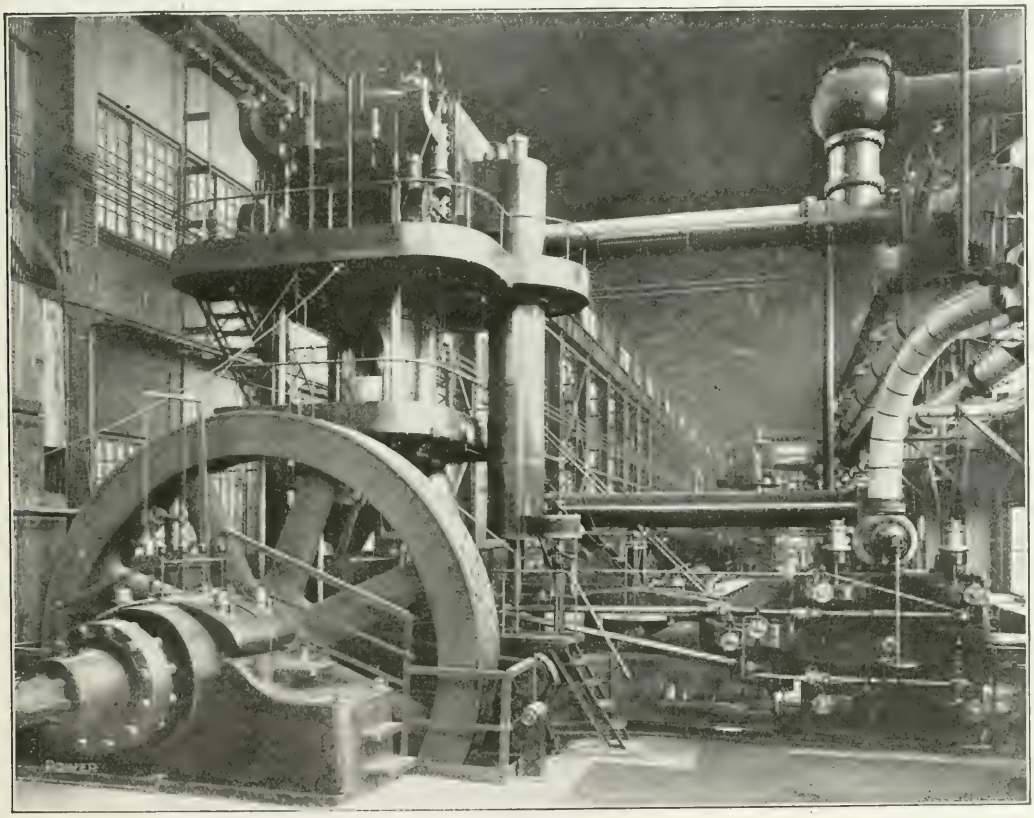


FIG. 1. ENGINE ERECTED IN STEEL WORKS

This engine is of exceptionally heavy design. Its bedplate is shown in Fig. 2, as it appeared when loaded on the special car that was necessary to transport it. This bed has guides of the four-bar type, and holds the horizontal high-pressure cylinder at one end; at the other end it supports a bell housing which carries the vertical low-pressure cylinder.

The shaft, crank and crankpin are forged in one piece, of fluid compressed nickel steel, both the shaft and the pin being hollow-forged. The former is 36 in. in diameter in the middle, reduced to 30 in. in the two bearings, each of which is 54 in. long. Since the crankpin is 24 in. in diameter, a built-up crank could not be used, for there would not have been enough metal left between the two holes in the crank. This solid-forged shaft was an exceedingly expensive feature, but the only way to avoid it would have been to have lengthened the stroke of the engine, thus not only making the cost of the engine greater, but requiring the erection of a higher building.

A distinctive feature of this engine is its valve-gear, which is shown in Figs. 3 and 4. This is of the Corliss straight-line type without wristplates, but with two eccentrics for each cylinder, thus permitting an extended cutoff. The steam valves are double-ported and of unusually large area as compared with the areas of the pistons. Very massive valve stems are carried beyond the tee-heads so as to be supported by sockets in the valves themselves. The outer ends of these valve stems are supported in spherical adjustable bearings carried by large brackets of box section. The valve

stems are thus entirely independent of the holes in the bonnets, and do not bear against the sides of these holes.

Every lever in the valve-gear is double, and the center of pull coincides with the center of support, so that there is no tendency to twist any part of the gear. There are no overhanging pins carrying a load. Consequently, no part of the valve-gear has any tendency to wear crooked, and in the clean engine room where the engines are situated, there should be very little wear at all.

The clips, being supported at both ends, are about twice as long as those usually provided on Corliss engines. With this great length, and with no tendency for the clips to get out of line, the edges wear much longer than is the case in an ordinary Corliss gear.

The engine is provided with a flywheel weighing 225,000 lb. and made in eight pieces. With a steam pressure of 150 lb. per square inch and a 27-in. vacuum, this engine frequently develops more than 7000 hp.

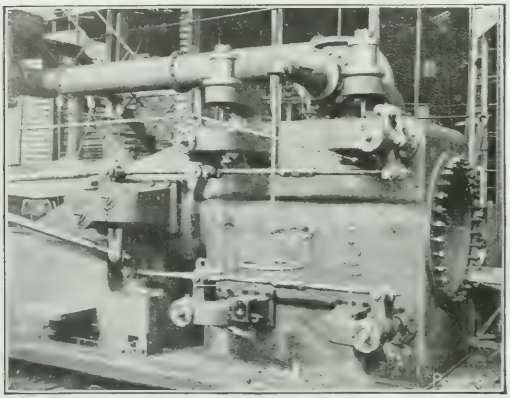


FIG. 3. HIGH PRESSURE VALVE GEAR

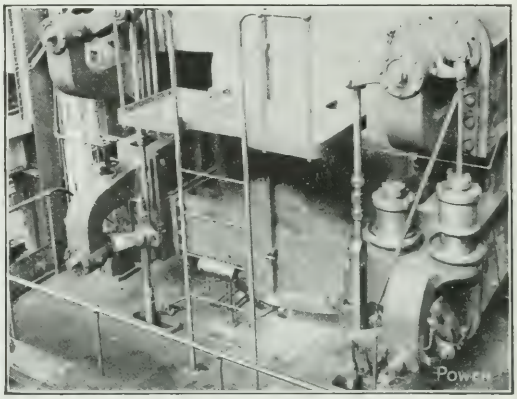


FIG. 4. LOW PRESSURE VALVE GEAR

FIG. 2. BEDPLATE ON FLAT-CAR

Rate of Combustion at Different Stoker Speeds

BY D. MCGREGOR

The operation of boilers equipped with chain-grate stokers suggested to the writer the advisability of having some tabulated data whereby, at a glance, it can be ascertained whether the firemen are working the fires to the best advantage for the load carried. Accordingly the table herein shown was figured out on the basis of bituminous coal weighing 55 lb. per cubic foot, burning on a grate 11 ft. wide, at an economy of 2½ lb. per kilowatt, giving the pounds per square foot, and the corresponding kilowatts at five different rates of stoker travel, and at depths of fuel ranging in half inches from 4 to 9 in.

Suppose, for instance, that the grate is traveling at the rate of 2½ in. per minute, with a 6-in. fire. In the column headed "2½ in. per min." and on the line representing a 6-in. fire, will be found 28.59 lb. as the rate of combustion per square foot of grate surface, which corresponds to an output of 1512 kw. at the rate of 2½ lb. of coal per kilowatt-hour.

It will be noted that practically this same rate of combustion can be had by running at 2 in. per minute with a 7½-in. fire, at 3 in. per minute with a 5-in. fire, or at 3½ in. per minute with a 4½-in. fire, and it becomes the duty of the engineer in charge to decide which rate is the most efficient. This can best be decided by a careful study of the character of the coal and of the ash discharged from the grate, together with the analysis and temperature of flue gases and the regulation of draft.

From this table has been deducted the following rule for finding approximately the rate of combustion: *Multiply the depth of the fire less ½ in. by twice the rate of feed in inches to get the pounds per square foot.*

POUNDS OF COAL PER SQUARE FOOT OF GRATE SURFACE AND EQUIVALENT KILOWATTS AT 2½ LB. PER KILOWATT-HOUR

Thickness of Fire, Inches	SPEED OF GRATE				
	1½" per min. 7½' per hour	2" per min. 10' per hour	2½" per min. 12½' per hour	3" per min 15' per hour	3½" per min. 17½' per hour
4	(603) 11 44	(805) 15 27	(1008) 19 09	(1210) 22 88	(1360) 25 70
	(680)	(907)	(1134)	(1360)	(1530)
4½	12 89	17 18	21 47	25 74	28 92
	(757)	(1010)	(1260)	(1510)	(1700)
5	14 30	19 09	23 84	28 60	32 13
	(834)	(1112)	(1386)	(1660)	(1870)
5½	15 73	21 00	26 22	31 46	35 34
	(911)	(1214)	(1512)	(1810)	(2040)
6	17 16	22 91	28 59	34 32	38 55
	(988)	(1316)	(1638)	(1960)	(2210)
6½	18 59	24 82	30 97	37 18	41 76
	(1065)	(1418)	(1764)	(2110)	(2380)
7	20 02	26 73	33 34	40 04	44 97
	(1112)	(1520)	(1890)	(2260)	(2550)
7½	21 45	28 64	35 72	42 90	48 18
	(1219)	(1602)	(2016)	(2410)	(2770)
8	22 88	30 55	38 10	45 76	51 40
	(1296)	(1714)	(2142)	(2560)	(2940)
8½	24 31	32 46	40 47	48 61	54 62
	(1373)	(1816)	(2268)	(2710)	(3110)
9	25 74	34 37	42 85	51 48	57 83

Figures in parentheses indicate load in kilowatts.

Closed Heaters, Surface Condensers

By Edward T. Turner

A chart for readily calculating the necessary surface in a surface condenser or closed heater, when the initial and final temperature differences between the steam and water are known, also the amount of circulating water.

The engineer is frequently confronted with the problem of determining the proper tube surface in a closed feed-water heater or a surface condenser. Although there are a number of empirical formulas used for this purpose, the results obtained by them are not consistent under all conditions of temperature of steam and water. The heat transmitted through the tubes is affected, among other things, by the material of which the tubes are composed, the size of the tubes, velocity of the water through or around the tubes, the period of contact between the water and the tubes, the temperature of the steam, temperature of the water into and out of the tubes, and the quantity of water used.

Regardless of all the variable quantities entering into the design of a heater or condenser, there is one law which can be depended upon, namely, the heat transmitted through the tubes is practically proportional to the mean temperature difference between the steam and the water. However, few experiments have been made to determine the quantity of heat transmitted per hour per degree mean difference in temperature between the steam and the water under the actual conditions met with in practice. A fair assumption for this factor, and one which is found to be about right in practice, is 300 to 350 B.t.u. per hour.

The curves shown on the accompanying chart are based upon the following:

Let

T = Temperature of the steam in the heater or condenser;

T_1 = Temperature of the entering water;

T_2 = Final temperature of the water;

d_1 = Initial temperature difference between the steam and the water;

d_2 = Final temperature difference between the steam and the water;

d_m = Mean temperature difference between the steam and the water;

Q = Weight of water in pounds per hour;

F = Square feet of tube surface per pound of water;

A = Total tube surface in square feet;

H = Heat transmitted through the tubes per degree mean difference in temperature between the steam and the water (in these calculations 300 B.t.u. is assumed).

The heat transmitted through the tubes is equal to the heat absorbed by the water.

$$\text{Heat transmitted through the tubes} = A \times 300 \times d_m \quad (1)$$

$$\text{Heat absorbed by the water} = Q\,(T_2 - T_1) \quad (2)$$

Equating (1) and (2),

$$A \times 300 \times d_m = Q\,(T_2 - T_1)$$

or

$$F = \frac{A}{Q} = \frac{(T_2 - T_1)}{300 \times d_m}$$

But

$$d_m = \frac{T_2 - T_1}{2.3 \log.^* \frac{d_1}{d_2}}$$

Therefore,

$$F = \frac{(T_2 - T_1)}{300\,(T_2 - T_1)} = 0.00767 \log. \frac{d_1}{d_2}$$
$$2.3 \log. \frac{d_1}{d_2}$$

or

$$F = 0.00767 \log. d_1 - 0.00767 \log. d_2$$

Plotting F as ordinates and $\log. d_1$ as abscissa, for various values of d_2, a series of parallel curves is obtained with a slope equal to 0.00767.

To use the curves, first calculate the initial temperature difference between the steam and the water, and locate this point on the abscissa. Next, move vertically to the slanting line which represents the final temperature difference between the steam and the water and horizontally to the scale at the left, showing the square feet of tube surface required per pound of water run into the heater or condenser per hour. Then to obtain the total tube surface required, multiply this constant by the quantity of water to be used per hour.

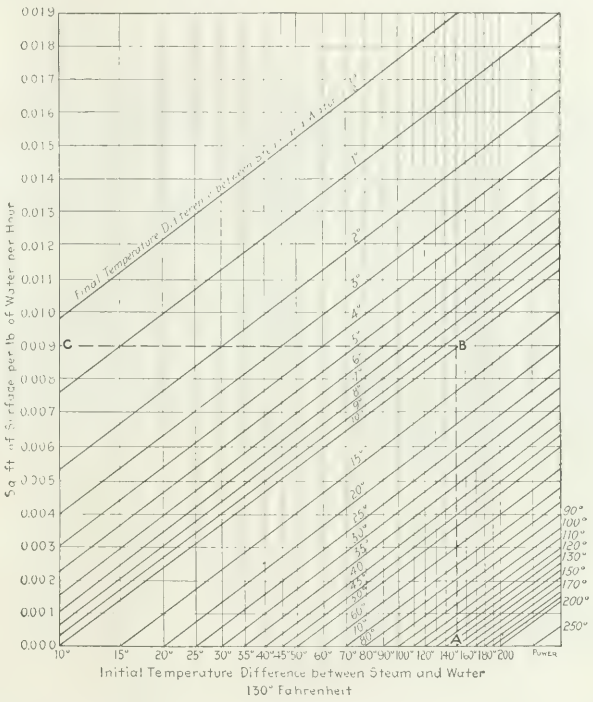


CHART FOR DETERMINING THE AMOUNT OF CONDENSING SURFACE REQUIRED

EXAMPLES

Determine the tube surface required in a feed-water heater to heat 30,000 lb. of water per hour from 62 to 202 deg.

*Common logarithms

with steam at 15 lb. pressure, absolute. In this case the initial temperature difference between the steam and the water is 150 deg., and the final temperature difference between the steam and the water is 10 deg.

Locate 150 on the abscissa, as at *A*. Move vertically to the slanting line marked 10, as at *B*, then horizontally to the scale at the left; this shows a constant of 0.009. Multiplying 0.009 by 30,000 lb., 270 sq.ft. is obtained as the required tube surface.

Again, assume that it is desired to find the tube surface in a surface condenser to maintain a 28-in. vacuum in a plant of 1000 boiler horsepower, when the initial temperature of the circulating water is 60 deg.; all the steam generated being condensed. The circulating water required is 940,000 lb., the initial temperature difference between the steam and the water is

$$100 - 60 = 40 \text{ deg.}$$

and the final temperature difference between the steam and the water is 15 deg.

From the diagram the square feet of tube surface per pound of water per hour is 0.0033. Multiplying this by 940,000 gives 3100 sq.ft. of tube surface for the condenser.

The tube surfaces determined by the use of these curves are for multi-current heaters and surface condensers. If the heater is the ordinary U-tube type, with the water flowing around the tubes, the surface as given by these curves should be multiplied by two.

Efficiencies in the Production of Power

By H. J. Macintire

Although decided improvements have been made within the past 25 or 30 years in the design of power-plant equipment, the fact still remains that there is considerable loss of energy between the grate and the busbars; this loss is due to incomplete combustion, radiation and conduction, cylinder condensation, friction, etc. In making a study of these losses they can best be separated into four divisions:

1. Efficiency of the boiler and furnace E_1. This is represented by the ratio of the heat given up to the water in the tubes to the heat value of the coal.

2. Thermodynamic efficiency E_2, which shows how near the actual engine approaches the ideal engine. This is represented by the Rankine cycle and is the ratio of the actual indicated work, expressed in heat units, to the heat supplied. The thermodynamic efficiency shows the maximum efficiency that can possibly be obtained with the pressure and quality limits in the problem. This loss in efficiency is unavoidable under the circumstances.

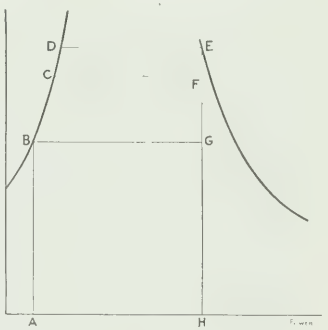
3. The next efficiency depends entirely upon the local conditions, such as cylinder proportions, steam leakages through ports, valves, stuffing-boxes, etc. This really shows how closely the engine approaches the Rankine ideal engine, which is nonconducting and in which leakages do not exist. This efficiency is equal to

$$E_3 = \frac{\text{Efficiency of real engine}}{\text{Efficiency of ideal engine}}$$

4. Mechanical efficiency, which is the ratio of the brake horsepower to the indicated horsepower. It varies with the design and workmanship, and in modern engines is almost independent of the load. Let this be designated by E_4.

Then the overall efficiency E is equal to $E_1 \times E_2 \times E_3 \times E_4$.

In the accompanying table of engine performances, it should be noted that



Elementary Temperature-Entropy Diagram

the first test is the report of one about 30 years ago, while the last is but a few years ago, the others having about equal lapses of time between. As E_2 depends on the upper and the lower limits of steam temperatures, the figures show how this has increased in recent years. Referring to the entropy diagram, the heat supplied is represented by the area *ABCFGHA*, and the work done by the area *BCFGB*.

$$E_2 = \frac{\text{Work done}}{\text{Heat supplied}} = \frac{BCFGB}{ABCFGHA}$$

If the boiler pressure be increased, keeping the back pressure the same, the additional work represented by the area *CDEFC* will be performed, and

$$E_2 = \frac{BCDEFGB}{ABCFGHA}$$

which is greater than in the first case; in other words, increasing the boiler pressure or decreasing the back pressure will increase E_2. In the tests quoted there has been a decided improvement from 14.95 per cent. in the case of a simple noncondensing high-speed engine to 30.7 per cent. in the case of a 8000-kw. turbine. The value of E_3, however, is the real test of improvement. This shows the advance in making pistons and valves tight, in proportioning the cylinder diameters and stroke, in the use of steam jackets and superheat, etc. These last are all means for reducing cylinder condensation and reëvaporation.

Kind of Engine	Steam Pressure Gage	Vacuum	Feed Water Temp., ° F.	Steam per I.H.P.	Superheat, Degrees F.	Efficiencies, Per Cent. E_1	E_2	E_3	E_4	E
1880 Simple, noncondensing, high speed	100		212	42		65	14.95	40.1	85	3.32
1890 Triple-expansion jacketed condensing	160	27	100	17		81	25 2	43.4	88	8.1
1895–98 Compound jacketed, condensing	160	26	118	13		77.5	24.2	46.6	94	8.24
1905 8000-kw. turbine	165	28 5		10.45	125	72	30.7	62.7	96	13.4
1905 Compounding condensing engines 5000-kw. plant oil fuel	189.3	28	150.7		92 8	83	31 2	54.9	91.75	13.45

The expression E_3 is a measure of the degree of perfection of the real engine to the ideal represented by the Rankine nonconducting engine. This ideal engine is supposed to have nonconducting pistons, cylinder heads and walls, and perfectly tight pistons, valves, packing, etc. Referring to the table, it will be seen that a gain has been made of 22.6 per cent.; that is, from 40.1 to 62.7 per cent. in the last quarter of a century. Advance in lubrication design and machine work are indicated by E_4, which has increased from 85 to 96 per cent.

The overall efficiency E is being obtained from the expenditure for coal. The increase in this factor has been from 3.32 in the first case to 13.45 in the last.

There are records of better tests, especially in the case of triple- or quadruple-expansion pumping engines having steam jackets and heaters. With all these, however, it is possible only to obtain less than one-fifth of the total amount of heat from the coal. From this it would seem that the steam engine, at its best, is a very wasteful and uneconomic appliance.

Tom Hunter, Hoisting Engineer

By W. O. Rogers

In which Hunter describes the Nicholson engine stop for preventing overwinding.

By means of this device it is impossible for the engineer to hoist when he should run the engine in the other direction.

The stop is designed to operate on shafts having several levels.

Hoisting 1200 tons of coal during a single shift is an everyday performance for many hoisting engineers. After a man has been throwing reversing and throttle-valve levers for hours at a time, it is no wonder that occasionally he gets confused and makes mistakes. It must be a good deal like trying to pat the top of one's head with one hand and at the same time perform a circular motion on the chest with the other. I put this up to Hunter one morning after breakfast and he agreed that there was a chance for confusion in signals.

"That is why automatic engine stops have been made for hoisting engines," said he. "When you come to consider that one-fifth of 1 per cent. of the total number of men employed in the anthracite-coal fields are killed, it is evident that too much attention cannot be paid to safety devices.

Record Hoisting

"While 1200 tons of coal is a good day's work, I recently read of a mine where 2840 tons of coal were hoisted 630 ft. in 7½ hours. That beats any record that I have ever heard of for a single shaft."

"Must have have had some mighty big cars," I observed, flicking the ashes from my cigar.

"The mine cars had a capacity of three tons, about the ordinary size, which means that for the entire 7½ hours of working time, the cars had to be dumped at the rate of two a minute, or one every 30 seconds. Maintaining this speed means that the cage must, through 7½ hours, travel 1260 ft. every 60 seconds, and stop twice, once to take on a loaded car and at another time to dump that car. Including the stop, the traveling speed of the cage must be 21 ft. per second in the shaft; excluding the stop, it must be twice that amount, which is going some."

"I don't see how the loaded and unloaded cars are taken off the cage at such a speed," I said. "It is so near being an automatic operation that I should suppose there would be an accident."

"There are accidents," replied Hunter, "lots of them. You see, one motion will both move an empty off and put a loaded car on the cage. In fact, as the cage checks its speed before stopping completely at the bottom of the shaft, the loaded car is set in motion. Thus, instantly the cage comes to a standstill, the loaded car moves into place, throwing the empty one off on the opposite side.

Danger from Fast Work

"That is where the danger comes from such fast work. The fact is, the signal is given to hoist before the cage has reached the bottom of the shaft. The footmen figure that the loaded car can be pushed onto the cage while the engineer is shifting his levers and getting started again. If the footmen have been slow and the car is but part way on when the cage starts, it is caught between the bottom of the cage and the top of the parting roof. Then something is going to smash. In the case I have in mind it would have been found that a single car can be caged, hoisted 630 ft., then dropped and returned to the shaft bottom in 20 seconds, which, if duplicated over and over again, means that three cars could be hoisted in one minute instead of two, and that means nine tons of coal a minute instead of six."

Want More Work

"That is going some for a fact, but I'll venture to say the owners of that mine are not satisfied with the fast work of their men, and that they will soon be looking about for ways and means of increasing this record output." I said this more from my knowledge of the way most good and willing workers are usually treated than from any knowledge of coal mining.

"Sure they will," answered Hunter. "It is simply a repetition of the biblical quotation, 'To him that hath shall be given.' It means that in most cases, and the owner of the mine now wants the men to see if they can't work a record of three cars per minute, or nine tons of coal per minute for one hour. This would mean an output of 540 tons per hour, or 4400 tons of coal for an eight-hour shift. There isn't an engineer living who could stand such going, but I have no doubt that it will be tried, and it will probably result in smashing something."

"One of these safety stops you speak of would come in handy under such conditions, I should judge," I said, as I arose and stretched myself, preparatory to taking a walk.

They Visit an Engine Room

"If you have nowhere in particular to go," said Hunter, "I'll take you to a hoisting plant equipped with one of these automatic stops, and you can see how it operates."

I jumped at the proposition, and in a short time we entered an engine room in which an automatic stop had been installed. Jones, the engineer, was a jovial fellow, and at noon time, when the engine was shut down, he took us down beneath the engine-room floor and showed us the mechanism of the device. It was a Nicholson automatic engine stop, and the engineer said that it worked to perfection. In fact, when he started up again, after dinner, he permitted it to operate, which demonstration showed the great value of the device. While examining the stop, Hunter explained its operation and construction in detail.

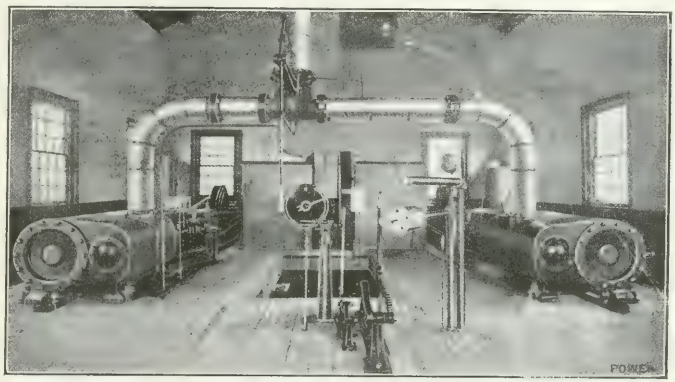


Fig. 1. Showing Engineer's Operating Levers

Nicholson Engine Stop

"The Nicholson engine stop," said he, "is constructed in two styles, that of the single-shift type for use where hoisting is done from one level, and that of the

double-shift type where tight and loose drums are used and the hoisting is done from any number of levels. It automatically adjusts itself and so removes any chance of failure on the part of the engineer to make any adjustments.

"The stop has control of the engine at each and every hoist and at any speed, and gradually cuts off the steam supply from the main or slide valve of the engine when the cage approaches the landing or dump, and so weakens the power of the engine, the slow application of the steam brake acting at the same time. It also does away with the danger of knocking the engine to pieces by continuous 'plugging,' as it is called, which is the favorite method of stopping."

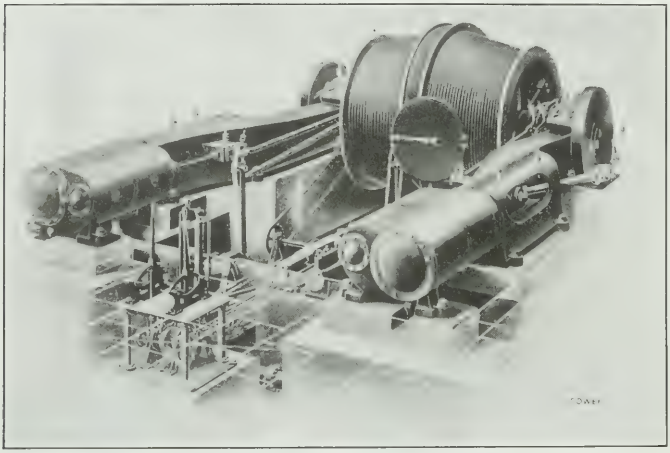


FIG. 2. SHOWING ARRANGEMENT OF ENGINE STOP UNDER FLOORING OF ENGINE ROOM

ACTS AT ANY SPEED

"Will it answer at any speed?" I inquired.

"Yes, no matter how fast or how slow," replied Hunter, "as the movement of the drum in either direction actuates the stop mechanism at a prearranged time, suitable to the hoisting conditions. The stop acts at every hoist on the main valve and does not interfere with the reversing of the engine at any time, as you might think. In fact, its action is always a positive warning to the engineer that the cage is approaching the landing, and if he is heedless of the warning by the action of the stop, the engine will be brought to a standstill before reaching the danger limit, making it necessary for him to manipulate his engine in order to reach the landing. The engineer usually has his hand on the lever in regular hoisting work, and when the lever begins to move he has warning that the cage is approaching the end of the hoist. If he fails to control the engine, because of a faulty throttle or other reasons, the stop will do it for him.

"There are cases where a speed limit is required in hoisting and provision has been made whereby it is set automatically by the stop when the increased speed limit is reached, and to automatically allow the engines to resume their normal speed again when brought under control.

ENGINEER CAN'T GO WRONG

"By the use of this stop it is absolutely impossible for the engineer to hoist up when he intends to go down, the machine having control of the engine in this respect, as the revolving disks are always operated at the danger point.

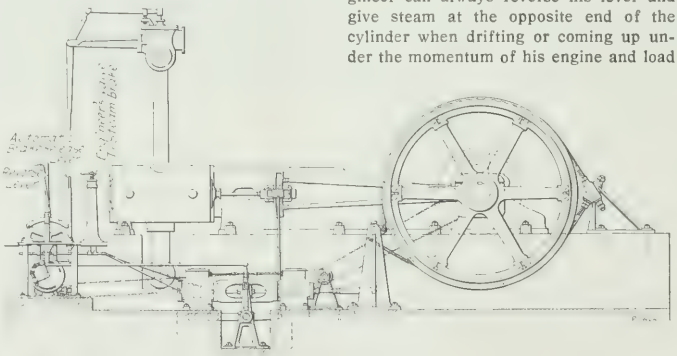


FIG. 3. ELEVATION OF ENGINE, STOP AND AUXILIARY STEAM CYLINDER

"The stop is operated by a sprocket wheel and chain, which works a worm and worm gear, and is arranged as shown in this sketch." And Hunter proceeded to sketch Fig. 3.

I afterward obtained photographs of the device, which are shown in Figs. 2, 4 and 5. By referring to the illustrations, Hunter's explanation will be easily understood.

"On the ends of the wormwheel shaft is a disk having two adjustable springs which press tappets (Fig. 4) against the face of the disk. These tappets are placed at a position equal to the travel desired. The tappets and disk revolve in either direction and come in contact with the extended end of the reversing lever, which moves toward the center of the quadrant. This hooks up the links of the engine and brings the steam valve to the cutoff position, thus closing the steam ports of the engine. At the same time the brake mechanism works in unison with the cutting off of the steam. The tappets are held against the reversing lever, and it can only be operated in the opposite direction."

"You mean that the engine cannot be started to hoist again until the link motion has been changed, and the engine run in an opposite direction to the first motion of rotation?"

"Just that. It is impossible for the cage to go up when it should go down. Under this shaft there is a disk for operating this steam valve, which shuts the brake slowly and takes up the momentum of the drum before the final application of the brake. This is adjusted so as to bring the engine to a stop before the danger limit is reached at either end of the hoist in case of a runaway."

ENGINEER CONTROLS THE ENGINE

"If this stop controls the engine, as you say, and as I have seen it do, I should think that it would interfere with the engineer in controlling the engine," said I.

"It doesn't," replied Hunter. "The engineer can always reverse his lever and give steam at the opposite end of the cylinder when drifting or coming up under the momentum of his engine and load to the landing, just the same as he does with engines not equipped with these stop motions."

"Well, how about lifting the cage from the fans, after it has rested upon them?" I next inquired; "there has to be some leeway for that."

"The mechanism is adjusted so as to

allow the engineer to lift the cage from the fans, and then reverse and go down. It works equally well when dumping cages are used. As the cage nears the curved guide it gradually slows up as the travel of the engine valve is diminished, and the steam brake gradually set for the prearranged limit of the hoist. It is only necessary to throw a lever to shut off the steam supplied to the brake. If it is necessary to give a little more valve opening after the reverse lever begins to move toward the center, a special

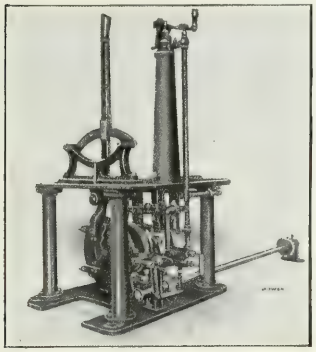


FIG. 4. DETAILS OF AUTOMATIC ENGINE STOP

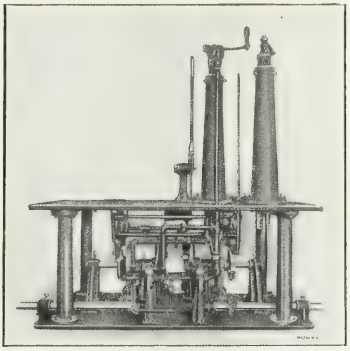


FIG. 5. STOP FOR USE WITH A NUMBER OF LEVELS

device allows the engineer to give the engine a little more steam."

"How about the cage that is nearing the bottom of the shaft?" I asked. I did not quite understand how the stretch of the rope, due to the load on the cage nearing the top of the hoist, could be taken care of and at the same time have the stop so adjusted as to take care of the empty cage at the bottom of the shaft, which had practically no stretch in the rope.

"Well," laughed Hunter, "the rope on the empty cage will be the same on both sides of the hoist, so if the rope on the loaded car is stretched more than that on the empty car, the conditions will be reversed on the next trip. For that reason the cage will always reach the bottom of the shaft at the same time the engine is stopped."

A Good Investment

"Of course, that is so simple I wonder I did not think of it before. It seems to me that there are so many accidents to hoisting machinery that it would be a safe investment to install a stop on every hoisting engine at the mine, whether used on shaft or slope work."

"Well, I've seen smashes that would take considerably more money to repair than an engine stop would cost, but it is a good deal like locking the stable door after the horse has been stolen. Some people do not learn by experience. They seem to think that all of the accidents will occur with the other fellow, and act surprised when something happens to their own outfit. You know some men are called 'lucky.' People have applied that term to me, but I do not consider it as luck at all; it is merely the result of forestalling accidents by removing the cause as far as possible by using safety devices, keeping the machinery in repair, and watching for weak spots and defects. One can learn a whole lot by noting the causes of accidents to others, and then looking over his own plant to see if the same condition exists there."

Another Smash

We finally bid good-by to Jones, the engineer, and, jumping on a passing trolley, were soon back at the hotel. Picking up an evening paper, I saw the headlines, "Engine Gets Away from Engineer. Head Work Demolished, Three Men Killed." "Another instance of useless slaughter, when a simple little device would have prevented it," I whispered under my breath as I entered the elevator and went to my room.

A Modern Pumping Plant in Mexico

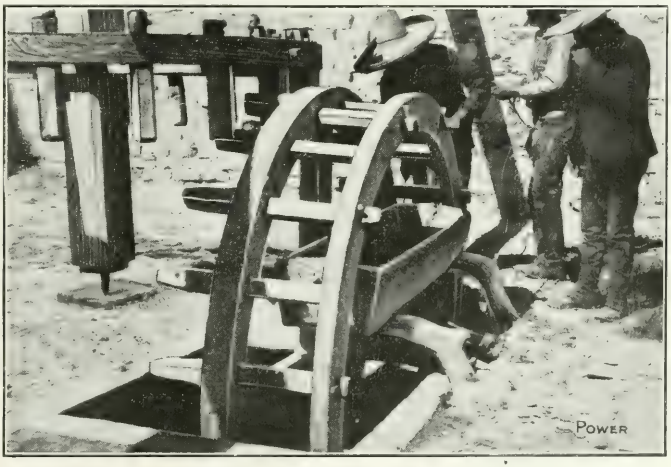
By Kirby Thomas

Herewith is shown a view of a "modern pumping installation" in Mexico, which device is intended to raise water about 60 ft. Power is derived from a mule attached to a sweepstake that is direct-connected to the horizontal drive wheel. Note the "accuracy" of the meshing between the drive wheel and the vertical load carrier.

A double rope arrangement with leather buckets of about 2 gal. capacity each passes over the vertical drum wheel and empties the water when at the top of the wheel into the wooden trough, which is set under the rim of the drum, by an arrangement of the spokes on the side.

This "installation" is new, but it is an exact duplication of another pumping equipment on the same *hacienda* which bears on the rock work of the building the date 1787, and a later inscription, "remodeled 1830." The longevity of the device is thus attested to authentically.

This "modernism" in mechanics is in sight of a trunk line of railroad and near one of the large cities of the northern part of Mexico.



MODERN PUMPING PLANT IN MEXICO

Swedish water-power developments in 1911 were increased some 80,000 hp. Of this increase, 70,000 hp. was made available by privately owned plants and 10,000 hp. to the state-owned Trolhättan plant.

Results from Burning Screenings

By J. F. Mowat

Showing the highly satisfactory results of burning screenings with the aid of a balanced draft.

Screenings were formerly not only useless but entailed much expense for their disposal.

It is the purpose of the writer to show what may be accomplished with a very low-grade fuel, when conditions are kept right. In this case the fuel was byproduct coke breeze, or screenings, containing nearly 20 per cent. of moisture and having a heat value of less than 10,000 B.t.u. as fired. In addition to this handicap, the fuel was so small that it was impossible to burn it under ordinary conditions, much of it looking like dirt, and the greater part would have passed through a $\frac{3}{16}$-in. screen.

The prevailing opinion has been that it is as easy to burn sand as this kind of fuel, until it was tried with a balanced draft. The results obtained are encouraging, as this byproduct can now be burned with economy when heretofore it has been considered worthless.

The boiler tested was a Stirling and the balanced draft was had by sealing the ashpit and forcing air into it with steam blowers; then regulating the damper until the pressure in the combustion chamber was zero. The pressure in the ashpit, corresponding to a given steam pressure at the blowers, was determined by the rate of firing. That is, the harder the boiler was forced, the greater was the steam pressure required at the blowers. A 6-in. bed of fuel was maintained by frequent light firing. Every two or three minutes the fire was stirred up on top and leveled off. This treatment, which was found essential to satisfactory operation, exposed new surfaces of the coke to the air, and hastened combustion. It was necessary to clean the fires every two hours, but as no cold air was drawn into the furnace, there was little loss from this source.

The remarkable part of these tests was the large amount of water evaporated and the ease of regulating the air supply. As will be seen, the boiler during the two tests developed 141.1 and 153.4 per cent. of its rating, with efficiencies of 54.31 and 53.48 per cent., which, considering the poor grade of fuel and the high rate of evaporation, are good; and are largely because the excess air was kept at a minimum. During the first test it was 52 per cent. and at the second only 31 per cent. Another factor in maintaining the efficiency was that, due to the balanced draft, no cold air was drawn into the boiler during the frequent cleanings. With so many, the cooling effect would have been undesirable, had natural draft been used.

It seems probable that satisfactory results might be attained by applying this method to burning low grades of slack coal, as there is little trouble with clinkers, as the body of the fire is undisturbed during leveling, and the steam from the blowers keeps the clinkers soft.

The following are the observations and results of the tests, the amount of steam used by the blowers, which was determined by actual trial, being deducted.

The water was measured in calibrated barrels, the fuel was weighed on platform scales that had been tested just before the boiler tests, and all the instruments used were calibrated. The tests were run by the alternate method.

RESULTS OF BOILER TESTS

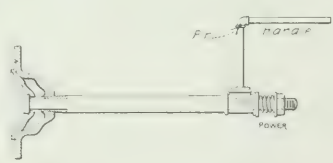
Kind of boiler	Stirling	
Duration of tests, hours	8	
Water heating surface, sq.ft.	3080	
Grate surface, sq.ft.	62.4	
Ratio of water-heating surface to grate surface	49.41	
AVERAGE PRESSURES AND TEMPERATURES	First	Second
Steam pressure by gage, lb. per sq.in.	100.3	111.6
Draft in furnace, inches of water	0.00	0.00
Draft in stack, inches of water	0.613	0.750
Pressure in ashpit, inches of water	0.877	0.972
Temperature of stack gases, deg. F.	590	646.0
Temperature of feed water, deg. F.	48.5	47.2
Temperature in calorimeter, deg. F.	245.9	260.9
Steam pressure at blowers, lb. per sq.in.	94.3	101.8
FUEL		
Total weight of coke breeze fired, lb.	22,901	24,[illegible]
Moisture in coke, per cent.	19.37	18.[illegible]
Total weight of dry coke, lb.	18,465	19,[illegible]
Total weight of refuse, lb.	4,602	3,[illegible]
Per cent. of refuse	24.92	20.38
Total weight of combustible, lb.	13,863	15,770
Dry coke consumed per hour, lb.	2,308	166
Dry coke consumed per sq. ft. of grate per hr., lb.	36.98	9.52
WATER		
Total weight of water pumped into boiler, lb.	103,814	112,961
Quality of steam, per cent.	98.01	98.00
Weight of water actually evaporated per hr., corrected	12,711	13,776
Factor of evaporation	1.2079	1.2116
Equivalent weight of water evaporated to dry steam per hour from and at 212 deg. F., lb.	15,357	16,691
Equivalent water used per hour by blowers, assuming 50 deg. superheat, lb.	359.5	386.5
Percentage of steam generated used by blowers	2.34	2.31
Net equivalent water evaporated to dry steam per hour from and at 212 deg. F., lb.	14,997	16,304
ECONOMIC EVAPORATION		
Water evaporated to dry steam per lb. moist coke, lb.	4.44	4.57
Water evaporated to dry steam per lb. dry coke, lb.	5.51	5.58
Water evaporated to dry steam per lb. combustible, lb.	7.33	6.98
Net equivalent water evaporated from and at 212 deg. per lb. moist coke, lb.	5.24	5.41
Net equivalent water evaporated from and at 212 deg. per lb. dry coke, lb.	6.50	6.61
COMMERCIAL RATING		
Builders' rating, at 10 sq.ft. of heating surface, boiler horsepower	308	
Commercial horsepower developed	434.7	472.7
Per cent. of builders' rating developed	141.1	153.4
EFFICIENCY		
Efficiency of boiler and furnace, per cent.	54.31	53.48
COAL ANALYSES		
Coke:		
Volatile matter, per cent.	1.76	1.61
Fixed carbon, per cent	64.77	66.14
Ash, per cent	14.10	14.16
Moisture, per cent	19.37	18.09
B.t.u., dry	11,613	12,001
B.t.u., as fired	9,375	9,830
Clinker:		
Combustible, per cent.	29.13	28.78
Ash, per cent	70.87	71.22
Stack gas:		
CO_2, per cent	12.60	15.40
CO, per cent	0.17	0.25
O_2, per cent	7.30	5.05
N_2, per cent	79.93	79.30
Excess air, per cent	52	31

Grinding Tube Caps

BY WILLIAM DUNN

The accompanying illustration shows a device for grinding tube caps of a Babcock & Wilcox boiler. All that is necessary is a $\frac{3}{4}$-in. machine bolt 12 or 14 in. long, threaded 4 or 5 in. at the ends, and a piece of 1-in. pipe tapered to fit the bolt hole in the cap. A spring and nut are used to get different tensions while grinding the cap with emery and oil. If the header is hot, machine oil should be used; if cold, use kerosene.

My idea is to have the caps ground on



DEVICE FOR GRINDING TUBE CAPS

their respective seats; then coat with graphite and cylinder oil. One should be sure to cover the whole seat with this preparation as it will keep the exposed portion of the seat from wasting away. I prefer to use cylinder oil for such work instead of boiler linseed oil, as the latter makes it too hard to remove the cap nut.

I also had experience in replacing tube caps of a Babcock & Wilcox boiler which had on several previous occasions been ground by applying them to a wooden board smeared with emery. Consequently the caps were almost ruined as the face had been beveled toward the outside edge; as a result paper gaskets had to be used to keep the cap tight.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Transformer Connections

Single-phase transformers are more widely used than polyphase transformers, even in polyphase systems, for the reason that greater flexibility and interchangeability are thereby obtainable.

Single-phase distribution is generally used for a lighting system, but for power transmission and distribution either the two-phase or the three-phase system is usually preferable.

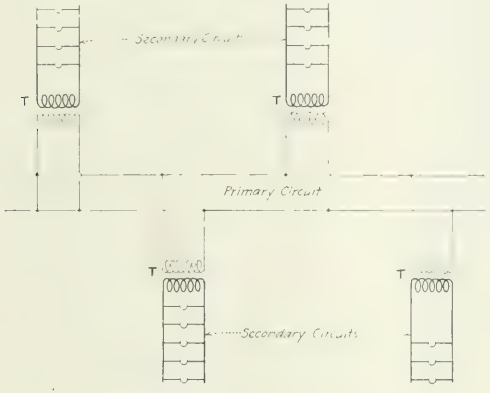


FIG. 1. SINGLE-PHASE DISTRIBUTION

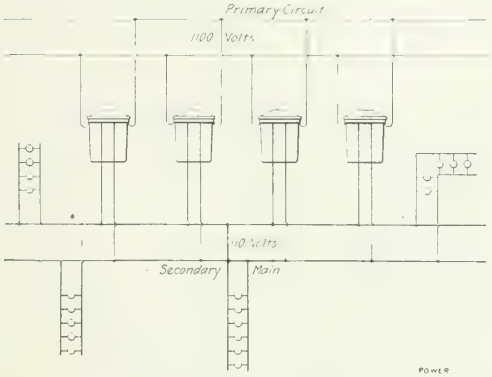


FIG. 2. FOUR TRANSFORMERS "BANKED".

SINGLE-PHASE CONNECTIONS

A typical single-phase circuit for furnishing current to lamps and motors is shown diagrammatically in Fig. 1. The primary windings of the transformers *T* are connected in parallel to the high-voltage primary circuit and the current-receiving devices are connected in parallel across the low-voltage distribution circuits connected to the secondary windings of the transformers. This system automatically maintains almost constant electromotive force in the secondary circuits and permits great flexibility of distribution from those circuits.

When a large load is concentrated at one place, the transformers may be "banked"; that is, the primary windings of several transformers are connected in parallel across the primary circuit and the secondary windings are similarly connected across the secondary circuit, the load being thereby divided between the several transformers. Fig. 2 shows four transformers connected in this way. It is preferable not to "bank" transformers, because of disproportional load division between them; when it is done, all of the transformers should be of the same make, size and type.

Transformer leads are generally connected to the windings so that the instantaneous direction of flow of the current in certain selected leads is the same in all transformers of the same type. For example, referring to Fig. 3, the transformer shown is connected inside so that when the current flows inward in the primary lead *A* it flows outward in the secondary lead *C*. Some such system is advisable in order that transformers may be readily connected in parallel; by this means it is only necessary to connect similar primary and secondary leads on different transformers for parallel operation.

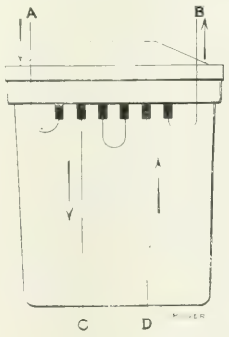


FIG. 3. INSTANTANEOUS POLARITIES

To make sure that a transformer is identical in this respect with other transformers of a different make, a polarity test is necessary. This is advisable to avoid the possibility of connecting the transformers in such a way as to short-circuit the windings. The polarity may be tested in the following manner: In Fig. 3 the primary lead *A* should be of the same instantaneous polarity as the secondary lead *C*. The primary lead *B* is connected to the secondary lead *C*, and an electromotive force of approximately 100 volts is applied to the primary leads *A* and *B*. The voltage measured from *A* to *D* should be greater than the applied voltage if the transformer is correct in polarity; if it is less, then the leads *A* and *C* are not of the same polarity, and either the primary or the secondary leads should be "crossed" if the transformer is connected in parallel with others which have the standard relative polarities.

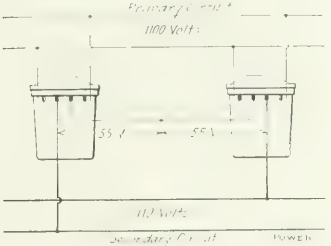
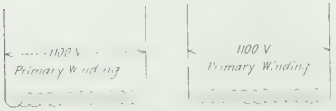


FIG. 4. TRANSFORMERS IN SERIES ON SECONDARY SIDE

Sometimes it is desirable to connect two transformers with their secondary windings in series across the distribution circuit, as indicated in Fig. 4. By this arrangement of connections, twice the secondary voltage is secured that would be obtained if the secondary windings were connected in parallel as usual. In connecting the secondary windings in series, those leads must be connected to



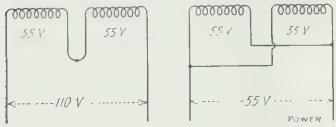


FIG. 5. SERIES SECONDARY CONNECTION

FIG. 6. PARALLEL SECONDARY CONNECTION

each other which are of *opposite* polarity at any given instant. Otherwise the two transformers will oppose each other and no secondary current will be delivered.

Transformers are usually built with the secondary winding divided into two equal sections, and some have both primary and secondary windings divided. With a transformer having a divided secondary winding it is possible to obtain either one or two secondary voltages without banking, because the sections of the secondary winding can be connected either in series or in parallel. Fig. 5 is a diagram of a transformer with two secondary windings connected in series, which gives a secondary voltage twice as high as that obtained when the secondary windings are connected in parallel as represented in Fig. 6. In connecting the secondary sections in parallel, the same precaution against short-circuiting the windings must be observed as when separate transformers are banked.

The object of providing a divided primary winding is to allow the transformer to be used on either of two voltages, one twice the other. For example, if each half of the primary winding is designed for 1100 volts, with the two halves connected in parallel, the transformer can be used on an 1100-volt primary line, and by connecting the primary windings in series the transformer may be used on a 2200-volt line.

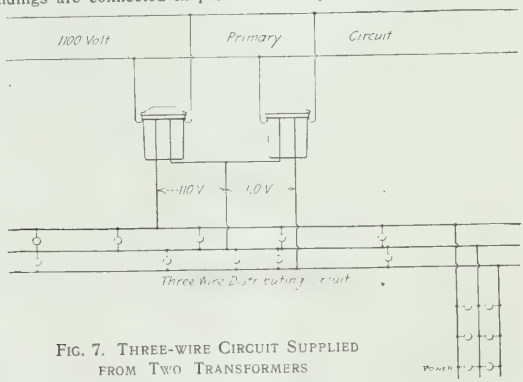


FIG. 7. THREE-WIRE CIRCUIT SUPPLIED FROM TWO TRANSFORMERS

THREE-WIRE DISTRIBUTION

In Fig. 7 two separate transformers are represented, each wound for a voltage ratio of 10 to 1 (that is, 1100 volts at the primary terminals and 110 volts at the secondary) and connected at the secondary leads so as to supply a three-wire system with a voltage of 220 between the outside conductors. The secondary windings are therefore connected in series, giving 220 volts between the outside leads. A lead is carried from the point where the secondary leads are connected together to the neutral conductor of the three-wire system, in order to obtain the secondary voltage (110) of each transformer between the neutral and each of the main wires. This method of connection gives a system which is almost the exact equivalent of the regular direct-current three-wire system. The secondary windings of the transformers correspond to the armatures of the direct-current dynamos. The only point in which similarity fails is in the voltage regulation. Both of the direct-current dynamos can be regulated, and independently of each other, but the transformer voltage cannot be regulated at all except by the use of very special, complex arrangements.

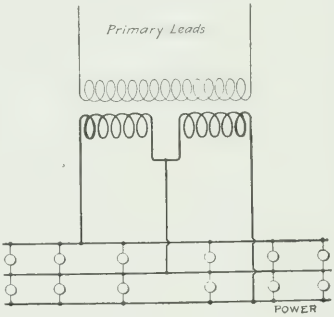


FIG. 8. THREE-WIRE CIRCUIT SUPPLIED FROM ONE TRANSFORMER

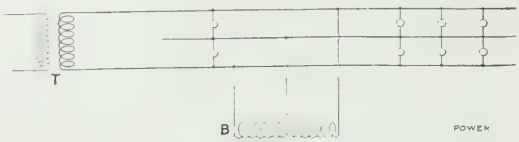


FIG. 9. THREE-WIRE CIRCUIT BALANCED BY AUTOTRANSFORMER

Fig. 9 shows still another method of connecting transformers for supplying a three-wire secondary circuit. The main transformer *T* is connected to the outside wires of the three-wire system and a balancing transformer *B* is connected to all three wires near the center of distribution. The current capacity of the balancing transformer need be only enough to carry one-half of the greatest difference in load between the two divisions of the system.

A balancing transformer for this purpose is merely an autotransformer with an intermediate tap midway between the terminals of its single winding; this tap is connected to the neutral wire, as shown. If one-half of the three-wire system is loaded more than the other half, there will be a corresponding increase in voltage drop on the heavily loaded side. The half of the balancing transformer connected to the lightly loaded side of the system will aid the half connected to the heavily loaded side and tend to raise the voltage to normal. Its operation corresponds to that of the balancing set used on a three-wire direct-current system supplied by one dynamo.

LETTER

Treatment of Commutators

My experience with small dynamos running 15 hours out of 24 has shown me that they will warm up considerably, especially if they are loaded to their capacity, and the brushes will spark if no preparation or lubricant is used on the commutator; refined paraffine is the best spark cure I have ever used. I would like to know if other engineers have used paraffine for this purpose or if anyone knows of something better?

J. E. FLASH.

Crowley, La.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Dugald Clerk on the Diesel Engine

In the issue of Apr. 9 we printed an abstract of a paper which was read recently by Dr. Rudolph Diesel before the Institution of Mechanical Engineers of Great Britain. As stated in the abstract, the paper consisted largely of a historical review of the development of the Diesel engine. The discussion of the paper was opened by Mr. Dugald Clerk, the well known English authority on internal-combustion engines, who paid Dr. Diesel

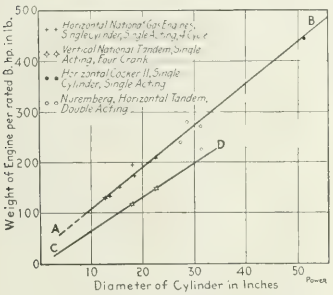

Horizontal National Gas Engines, Single Cylinder, Single Acting, 4 Cycle
Vertical National Tandem, Single Acting, Four Cranks
Horizontal Lücker II, Single Cylinder, Single Acting
Nuremberg, Horizontal Tandem, Double Acting
Weight of Engine per rated B. hp. in lb.
Diameter of Cylinder in Inches
A
B
C
D

FIG. 1. COMPARATIVE WEIGHTS OF DIFFERENT SINGLE-CYLINDER ENGINES

a warm tribute for his originality and his perservering struggles during the pioneer period. He regarded Dr. Diesel as one of the greatest living inventors.

Mr. Clerk then pointed out that the idea of compressing air alone in the cylinder and then injecting fuel into that air, in either a gaseous or a liquid state, was not a new one at the date when Dr. Diesel took up his work. Some twenty-five years ago (in 1887) he (Mr. Clerk) had built an engine in Birmingham of the two-stroke-cycle type, in which air was sent into the motor cylinder, compressed in the compression space, and a separate pump for compressing gas forced gas into the cylinder, this gas igniting as it entered the cylinder; this was a constant-pressure type of engine. In 1888 he had built two engines of that type. Thinking that Dr. Diesel would like to see some of the indicator diagrams taken in 1887 and 1888, he brought a few of these diagrams showing the action of the injection, and also some diagrams showing the action of the flame in the cylinder. From a running point of view the engines were very good, but as he could obtain greater economies with explosions, he had not carried the matter further. It had, however, led him to take a great interest in the theory of the constant-pressure engine.

In an early paper, contributed to the Institution of Civil Engineers in 1882, he had developed the theory of the internal-combustion constant-pressure engine very fully, and had shown the laws it was necessary to observe in order to obtain in theory the highest efficiencies possible. On the formula developed by him in 1882, and explained in his book in 1886, he had worked out the air-cycle efficiency of the Diesel engine. He had found that calculating the air-cycle efficiency of the Diesel engine from its compression space, if it lost no heat at all, and had air alone as a working fluid, the theoretical efficiency would be 0.56.

DIESEL EFFICIENCY

It appeared to him that some of the results obtained by Dr. Diesel or others for indicated efficiencies were too high. That, however, was merely a scientific criticism. He had always regarded the published indicated efficiencies of the Diesel engine as being almost all too high, for the reason that in calculating the indicated power of the engine the positive diagram above the compression was taken for the mean pressure. That positive diagram, however, included a certain proportion of work given by the high-pressure compressed air coming from the compressors. Continental engineers had considered that this was a friction loss, and should enter into mechanical efficiency computation. He differed from this view; it should not be calculated in the mechanical efficiency at all, but should be considered one of the thermodynamic elements. Calculated in that way, it would be found that the Diesel diagram would give something under 40 per cent. indicated efficiency. He could not agree that 48 per cent. indicated efficiency had ever been obtained; it did not in the least affect brake results, but it did affect the pure thermodynamics point of view.

Taking 0.56 as the highest air efficiency, with the expansions used, then, according to a great many experiments made by English engineers, a higher economy than 0.7 could not, by theory, be obtained. Multiplying 0.56 by 0.7, the result was 0.39. Dr. Diesel had actually got the very high efficiency of about 39 to 40 per cent., but he considered as erroneous the 48 per cent. which was mentioned in the paper.

By the final method that all must ultimately take—the brake power developed for a given oil consumption and given heat units—the Diesel engines gave somewhere about 0.30.

The Carels engine in 1905 showed an oil consumption at not quite full load of 0.444 lb. per brake horsepower. From the thermal value of the oil given at the same time, he calculated a brake thermal efficiency of 29½ per cent. Then the indicated thermal efficiency came out as 38½ per cent.—a very notable efficiency. In 1908 an American Diesel engine gave 29.2 per cent. brake thermal efficiency, while another gave 28.1. Recent tests of Mirrlees engines, made at Stockport, gave 31½ per cent. He thought he might say that the usual maximum brake thermal efficiency of a Diesel engine ranged from 29 to 32 per cent.

COMPARISON WITH GAS ENGINES

Mr. Clerk then stated that from any good gas engine with a compression ratio of about 5½ it was possible to get, in brake horsepower, 30 per cent. of the heat given to the engine cylinder with any form of gas; as much as 35 per cent. might be got—supposing the mixture were not compressed high enough to preignite. If, however, certain little precautions were taken, such as putting in a little exhaust gas (as he had often

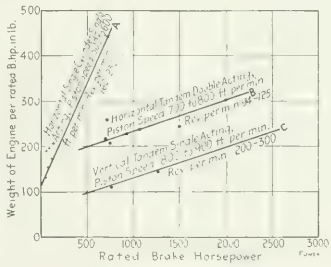


FIG. 2. COMPARATIVE WEIGHTS OF DIFFERENT TYPES OF ENGINE

done), efficiencies up to 33 per cent. and 34 per cent. might be reached and maintained. No commercial gas engines, however, gave 34 per cent., because the compression was a little too high and required the use of carbonic-acid gas to keep down preignition. About 32 per cent. was the regular thing.

He differed from Dr. Diesel in thinking that there was any special efficiency from a thermodynamic point of view in

the Diesel type of engine. The great advantage of the Diesel engine did not lie in that. He said he would undertake to build a compression engine with an expansion sufficiently long to give any thermal efficiency, either indicated or brake, which Dr. Diesel might get with his type; he would use the explosion type and leave the other to Dr. Diesel. To carry out such a proposition, however, it would be necessary to make a very much heavier engine than he was accustomed at present to build. As Dr. Diesel had said, the Diesel engines were much heavier than the ordinary type; bearing the weight of 500 lb. to 600 lb.

TABLE 1. WEIGHTS OF LARGE CONTINENTAL GAS ENGINES OF THE TANDEM DOUBLE-ACTING FOUR-STROKE TYPE

B.hp.	Net Weight of Engine with Fittings, without Flywheel	Net Weight of Flywheel	Weight of Engine per B.hp.	Weight of Flywheel per B.hp.
	tons	tons	lb.	lb.
2000 ..	266.5		298.5	
1500 ..	162.3	34.5	242.5	51.3
1060 ..	109.3		231.0	
1000 ..	120.0		269.0	
950 ..	95.1	25.0	224.0	58.8
800 ..	85.0		238.0	
750 ..	68.5	17.7	204.5	52.6
700 ..	81.7	15.7	261.0	50.2
630 ..	66.5		237.0	

in mind, he presented in Table 1 particulars of a number of Continental engines, varying from 237 lb. per brake horsepower at 630 hp. up to 298 lb. at 2000 hp. [The figures for the 750-hp. engine appear to be inconsistent.—EDITOR.]

A characteristic of the gas engine, he said, is that as the cylinder diameter is increased there is an increase in weight per brake horsepower. The diagram reproduced as Fig. 1 herewith shows this characteristic plotted in the case of a number of recent horizontal single-cylinder gas engines. The points represent different makes of engines; at the top right-hand corner a point represents one of the great Cockerill engines, with 51¼-in. cylinders. This engine weighed 440 lb. per brake horsepower. A new "National" vertical tandem, with a 22-in. cylinder, weighed 110 lb. per brake horsepower; this engine was represented on the line *CD*.

In the case of single-acting engines very big weights were reached, and the weight per horsepower increased enormously. This was the reason why Dr. Diesel had found it necessary to turn his attention to the two-stroke engine, and the speaker was interested in that fact.

In Fig. 2, Mr. Clerk showed lines representing several types of engines to bring out the differences between the various types. One example showed about 440 lb. per brake horsepower. Particulars of all these engines are given in Table 2. In the case of Dr. Diesel's 800-hp. engine (he believed the power was 200 hp. per cylinder), the weight was considerably heavier than any of these, being about 600 lb. per brake horsepower. The foregoing observations, Mr. Clerk contended, showed how necessary it was to go to the two-stroke cycle; by building double-acting two-stroke engines, the weights for engines of the same speed could be reduced to 200 lb. per brake horsepower.

Dr. Diesel had managed, with great engineering ability, to go up to the 23-in. or 24-in. cylinder. But in designing the Diesel engine it was not only necessary to design for the 500 lb. per square inch in compression but also for the equivalent of preignition in ordinary gas engines. In gas engines it was usual to design for 400 lb. per square inch, and to allow an additional 120 lb. for preignition (520 lb. in all). In the Diesel engine, he understood, the design had to be not for the ordinary maximum pressure of 500 lb. but for 1000 lb.; because if, by any chance, the inlet valve got stuck, and it happened that anything went wrong while there was a charge in the cylinder and air was being compressed (as it was in 99 or more per cent. of cases with the Diesel engine), the mixture might be compressed, with the result that, unless enough metal had been provided, there might be a bad accident.

TABLE 2. PARTICULARS OF GAS ENGINES OF DIFFERENT DIMENSIONS AND TYPES

Rated B.hp with Coal Gas	Diameter and Stroke	Stroke Bore Ratio	Revolutions per Minute	Piston Speed	Weight of Engine	Weight per B.hp
	in. in.			ft. p.m.	tons	lb.
Horizontal "National" Gas Engines Single-cylinder, single-acting, four-stroke cycle						
57	14×20	1.538	230	495	3.33	131.0
68	14×21	1.500	240	537	4.08	134.5
85	16×22	1.375	210	500	5.82	153.5
105	17×26	1.530	190	539	9.08	193.5
125	18.5×28	1.513	180	555	9.48	170.3
150	20×31	1.550	170	567	13.20	197.7
185	22×34	1.545	160	587	17.05	206.5
Horizontal Cockerill Single-cylinder, single-acting, four-stroke cycle						
Rat'd B.h.p with Blast Furnace Gas						
800	51¼×55	1.07	75	470	160	448
Horizontal Continental Tandem, double-acting, four-stroke cycle						
800	28×34	1.21	130	736	85	238
1000	32×40	1.25	110	733	120	269
Vertical "National" Gas Engines Tandem single-acting, four-stroke cycle						
750	18×18	1.00	300	900	39	116.5
125	23×24	1.00	200	800	85.5	119

Enough metal had been provided in the smaller Diesel engines, but he did not see how this provision could be made in the case of the large cylinders. The difficulty arose beyond 24 in. diameter. He understood there was a Diesel engine with a 35-in. cylinder, but if he had to work with it he would be very cautious. He would be glad to know if there were any safety arrangement to get over the difficulty of a sticking valve. If Dr. Diesel could show what methods he proposed to adopt to get the large 30-in. and 40-in. cylinders, it would be useful.

In closing the discussion, Dr. Diesel agreed with Mr. Clerk as to the method of computing indicated efficiency and stated that Mr. Clerk's early work had been of much assistance to him in the early development of the Diesel engine.

Peat as Gas Engine Fuel

In a paper read before the Dublin Section of the Institution of Electrical Engineers, on Mar. 16, T. Tomlinson discussed as a commercial possibility the use of peat for power production on the bog, claiming two important advantages over its use as fuel off the bog: first, the peat so used need not have the water reduced below 60 per cent, and, second, the recovery of sulphate of ammonia in the process of gasifying the peat is commercially profitable under favorable conditions. The importance of the first point lies in the decrease of the cost of production, making possible a continuity of supply without expensive storage and double handling, while under the second reason, the cost of the fuel would be covered by the value of the sulphate of ammonia.

What Mr. Tomlinson regards as favorable conditions would be a continuous demand for 2000 hp. or over, a high percentage of nitrogen in the peat, a total cost of peat of a dollar per anhydrous ton, with a certainty of continuous production.

By surface drainage of the bog a possible saving in labor would be accomplished; while a more effective method would be a thorough bottom drainage of a portion of the bog cut off from the main bog, with local surface drainage of the cutoff portion. A suggested plan of testing the saving is to begin with what is known as the cut-away bog, or that part which has been left because it lay below the rim of the "containing saucer"; hence is not workable without bottom drainage. In this way the very best black peat would be available and the main and minor drains would not be of excessive depth—not more than 12 ft. in an originally deep bog.

Relying on drainage and evaporation, with protection from rain, or in a better way which might be found in actual practice, Mr. Tomlinson believes it to be possible to greatly improve the existing hand-cut peat industry and to provide fuel continuously and at low cost for industrial purposes.

With regard to the peat belt of Ireland, Mr. Tomlinson says it lies between a line drawn from Wicklow Head to Galway and another drawn from Howth Head to Sligo. The area of peat land is one-seventh the area of Ireland, equal to 3,000,000 acres or 4700 square miles. There is no part of Ireland which is beyond reach of power derived from this area. As to the value of the bogs, if they are assumed to be on the average of the same value as the Dutch bogs, 6 ft. deep, namely, $500 per acre, a total value is arrived at of $1,500,000,000.

Passing from the peat reclaiming side of the problem to its application, some particulars of the Crossley peat plant installed at Portadown will be given. The capacity of the plant is 400 b.hp., and the peat-fuel consumption, based on bone-dry fuel, amounts to 1.65 lb. per brake horsepower-hour. This figure being multiplied by the heat value of the peat gives

$$1.65 \times 8600 = 14{,}190 \ B.t.u.$$

Seeing that Crossley's guarantee with their ordinary suction gas plants using anthracite fuel, a full-load consumption not exceeding 0.8 lb. per brake horsepower-hour with anthracite fuel containing 14,800 B.t.u. per pound, giving 11,840 B.t.u. per brake horsepower, their guarantee for peat leaves a fair margin. The Portadown plant shows a saving of over $2000 per year. The following figures show the average gas analysis from peat gas obtained when using peat with 26 per cent. moisture contents:

	Per cent.
Co_2	11.4
CO	20.6
O_2	0.4
H_2	12.7
CH_4	3.5
Total combustible	36.8

Calorific value per cubic foot...140 B.t.u.

By the courtesy of the agents for the Power Gas Corporation, Mr. Tomlinson was enabled to give the following particulars of peat gas plants erected by that company: A 20-ton per day plant erected in Westphalia, Germany, was tested under the auspices of the Minister for Agriculture of Prussia, and in consequence of the satisfactory nature of these tests a large electric central station was erected upon a peat bog 25 miles from Osnabruck. This important town of 163,000 inhabitants has shut down its steam-driven station and is now taking power from the peat gas producer plant. The gas plant is capable of gasifying and recovering the byproducts from 210 tons per day of 24 hours of air-dried peat containing 60 per cent. of moisture. The gas drives three double-acting tandem gas engines, each of 1150 b.hp. coupled to alternators running in parallel. The current is also distributed over a radius of about 25 miles.

A central station is situated near Orentano, Italy, where gas is generated and byproducts are recovered from 100 tons of peat per day. Part of the gas is used in three 500-hp. double-acting gas engines driving alternators in parallel. The current is distributed over the surrounding district, and to the town of Pontedera, 14 miles from the plant. The supply has been uninterrupted since the starting of the plant two years ago, and the results have exceeded those guaranteed by the makers. The peat used contains 1.45 per cent. of nitrogen, and yields over 112 lb. of sulphate of ammonia per ton of theoretically dry peat.

The Power Gas Corporation claims to have developed a means of mechanically drying peat from 80 per cent. moisture to 50 per cent. moisture, independent of the weather conditions, at a total cost, including excavating, drying and all handling, of about 72c. per anhydrous ton.

CORRESPONDENCE

Doing the Wrong Thing First

When an engine goes wrong the operator is supposed to get busy and find out what is the matter. That is all right, but the question is where to begin. A recent experience with a gas engine would indicate that the proper thing to do first is to find out if you have not made some mistake yourself instead of assuming that the engine is designed wrong or has been improperly adjusted by the builders.

A stationary gasoline engine undergoing a series of brake tests when handled by one squad of students had acquitted itself creditably. When another squad took it in hand, the engine started and ran all right with no load but would not carry the load it had previously carried. The captain of the squad, stating that he would "make her go or bust," got some tools and proceeded to make adjustments. He found that the exhaust valve was badly adjusted, although it was all right a few minutes before. The spark also was not timed properly, so he "fixed" that. By the time he had everything "fixed," the engine could not be started at all.

IGNITER TRIP IN STARTING POSITION

What he ought to have done was to make sure that he had made no mistake himself. In this case the mistake consisted in not advancing the spark after starting. On the end of the trip rod which actuated the make-and-break igniter there was a loose block with shoulders on two opposite sides as in the accompanying sketch. In the position shown, the block *B* is right for starting. By turning the block over so that the cam face *A* would be underneath, the inclined plane rides the pin *C* sooner than the one now in alignment, and therefore breaks the circuit sooner. He had merely forgotten to turn the block over.

R. McLAREN.

Govan, Sask., Can.

Peculiar Cause of Journal Heating

Some time ago I had charge of a 750-hp. gas engine in a cement plant. The engine was direct-connected to a line shaft from which were driven two sections of Griffin mills.

When one mill section was taken off, the main bearing of the engine would heat up in about 15 minutes and then it would take about 3½ hours to cool before the load could be put on again. So long as both sections of mills were in operation, the bearing ran at normal temperature.

After going over the engine carefully in an effort to locate the cause and without success, it was decided that the trouble must be in the mill room. Investigation there disclosed the fact that repairmen had been working on the line shaft a few days previous and had left no clearance between the collars and bearings. When one section of the mills was thrown off, the collar on the main journal of the engine would hug the bearing tightly and, being in such a position as to receive only a small amount of oil, it would heat up in a very short time. After giving all the collars on the line shaft $\frac{1}{16}$ in. clearance, no more trouble was experienced with the main bearing.

C. J. BRICKER.

Carlyle, Kan.

A "Paint" for Exhaust Pipes

After experimenting with all kinds of heat-resisting paints for our gas-engine exhaust pipes, I happened to think of a stove polish. I argued that if it would stay on a hot stove, it would on the exhaust pipes, and after a trial I was convinced I had found relief from an eyesore to the plant.

We have about 50 ft. of exhaust piping above the floor, and the burnt aspect detracted from the otherwise cleanly appearance of the plant. Anyone who has failed to keep paint on hot pipes or other surfaces will find stove polish the solution of the problem.

J. W. FRIES.

Middleboro, Mass.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Central Refrigerating Plant at Atlanta, Ga.

By R. C. Turner

What is perhaps the largest and most modern ice and refrigerating plant in the South is the central plant of the Atlantic Ice & Coal Corporation, in Atlanta. This company operates a chain of refrigerating and ice plants extending from Richmond on the south, to Jacksonville on the south, a total of seventeen plants, all of which are operated during the summer months. But out of the total number of plants operated by the company the central plant in Atlanta is conceded to be the most efficient, and on account of being a combination plate and can factory it can produce ice continuously for less than 70c. a ton.

Located at the corner of Piedmont Ave. and the Georgia R.R., the plant is afforded exceptional railroad facilities, owning a side track and coal trestle which render the icing of refrigerator cars and the delivery of the coal supply a simple and economical operation.

Refrigerating Equipment

The refrigerating machinery has a capacity of 375 tons, 24 hours' rating, and consists of the following: two 100-ton ammonia compressors direct-connected to cross-compound Corliss engines of 350 hp. rating and a third machine of 50 tons capacity direct-connected to an 18x36-in. Corliss rated at 125 hp. These three machines have been in operation during the last three years. A fourth machine is being erected at the present time and is of 150 tons capacity direct-connected to a Corliss cross-compound of 500 hp. capacity. The work of erecting the new compressor is progressing rapidly and the new unit will probably be in regular service by the first of May.

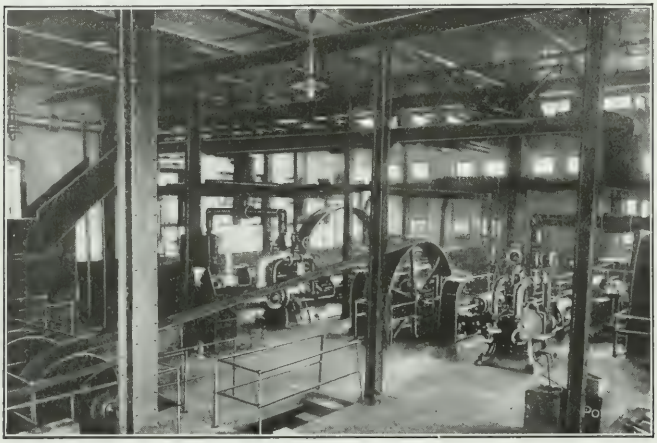


Fig. 1. Engine Room of Central Ice Plant, Atlanta, Ga.

All the ammonia compressors are of the standard double-acting type with extra deep stuffing-boxes to admit of the use of metallic packing; the stuffing-boxes are also equipped with an independent expansion valve so as to insure a cool rod under severe operating conditions met with when using the flooded system.

The freezing tank, which is 50x100x 10 ft. in the plate department, and is made of standard tank steel, is equipped with 100 five-ton freezing compartments. Six days are usually required to freeze a plate weighing five tons of 10,000 lb. When a plate freezes to the desired size the ammonia supply to this particular coil is cut off and the hot gas turned into the coil to loosen up the plate of ice so that it can be withdrawn from the tank with the aid of the hydraulic crane. It is then placed on the cutting table and reduced to any size of block desired. The water in the plate tank is kept constantly agitated with compressed air during the freezing process.

In the can ice department the freezing tank is also 50x100x10 ft., and contains 1064 standard 400-lb. block cans. The freezing bath employed is a chloride of calcium solution and the expansion piping is standard extra-heavy 2-in. pipe. The agitation of the brine is accom-

Fig. 2. Freezing Tanks in Plate Ice Room

plished with a set of double propellers and is driven by a 7-hp. motor. A new tank, which will double the capacity, is now nearing completion and will be in service at an early date. A feature of this tank is that all joints in the ammonia piping are welded, reducing the leakage to a minimum. In this department electric hoists are employed to lift the cans from the bath and place them on the steam table to loosen up from the can; after this the ice slides by gravity into the storage room.

The condensers are located on top of the building and are of the single-pipe type of extra-heavy 2½-in. piping made into headers 20 ft. in height. The water supply for keeping the condensers cool and supplying the plate tank with make-up water is obtained from two 500-ft. artesian wells. The wells are equipped with the usual deep-well air lift. The slide-valve engine which is used only in an emergency. The other two are driven from a countershaft which in turn is belt driven from the flywheel of the engine operating one of the ammonia compressors. To the same countershaft are connected generators which supply electric light and power for the plant.

The engines are operated condensing and are served by a set of standard surface condensers from which the condensed steam is passed direct into the supply tank of the distilled-water system; no condensation is returned to the boilers as these are at all times fed direct from the city water main.

Storage and Service

The plant has two ice-storage rooms having a combined capacity of 3000 tons. During the winter months, when the demand on the plant is at the minimum, these rooms are gradually stocked up to their full capacity. At the central plant 10 cold-storage rooms are operated for the convenience of the local fruit and produce dealers. A different temperature is maintained in each room, ranging from 10 deg. in the fish room to 34 deg. in the meat compartment.

The company also operates a refrigerating service for the convenience of the local packers and grocers who are within a radius of ¼ mile of the plant. The brine system is used; the underground pipe line supplying the service to the packers is made up of 5-in. extra-heavy pipe. For circulating the brine a centrifugal pump driven by a 5-hp. motor is used and a constant pressure of 20 lb. is maintained on the line. The temperature of the brine on leaving the pump is 12 deg. and on the return pipe of the system the temperature is usually about 10 or 12 deg. higher, being subject, of course, to the variation of the outside temperature. In the boxes at the packing houses the temperature ranges from 24 to 38 deg. The refrigerating service has been in operation for several years and has proved very satisfactory.

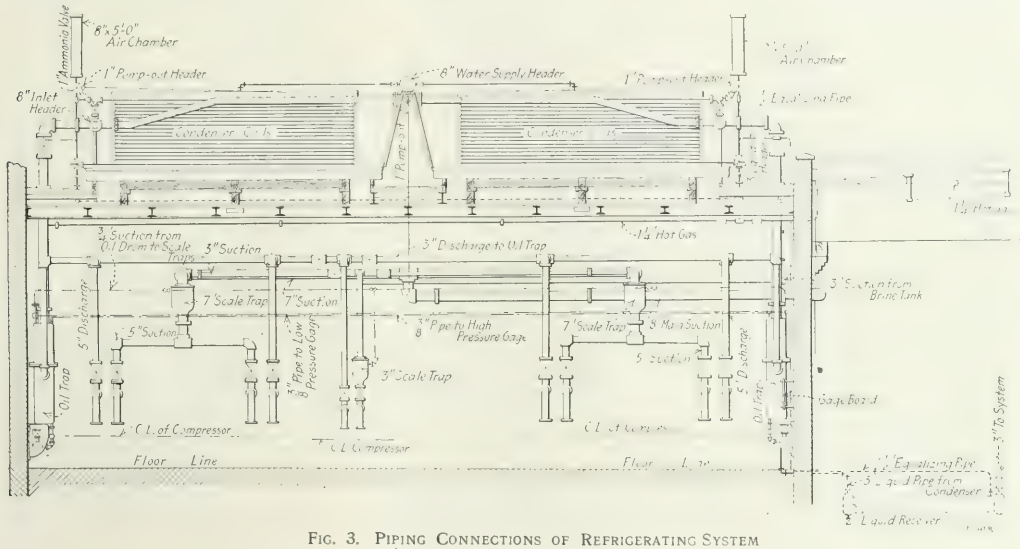


Fig. 3. Piping Connections of Refrigerating System

water is driven out under 80 lb. air pressure, flows into a receiving tank and is circulated over the condensers by a centrifugal pump.

Power Plant

Four 150-hp. return-tubular boilers are installed and operate at 150 lb. steam pressure. The boiler equipment is being supplemented at the present time, however, by the addition of three more units of the same size and type. When the additions are completed in the boiler room this department will have a capacity of 1050 hp. The water supply for the boilers is river water from the city water-works.

The plant is equipped with three air compressors of ample size to supply the needs of the plant. One of these compressors is direct-connected to a small

Plugging Leaky Tubes in Absorber

By Gay A. Robertson

In operating absorption machines, trouble and inconvenience are often experienced by leaks in absorber tubes, where the shell type of absorber is used. This is especially true when the tubes begin to get old.

Leaks most generally come in the upper part of the tube, depending upon the height the aqua is carried in the absorber. It seems that the hot gases in connection with the hot aqua pit the tubes, possibly attacking impurities in the iron.

Troubles of this kind, of course, always happen when one least expects them, and when ice is needed most. It therefore falls upon the engineer to make a quick temporary repair and get his plant going. The accompanying sketch shows a handy method of plugging a tube, using cast-iron plugs, and a bar to assist in starting the lower plug. The sketch shows the shell of an absorber, with a 2-in. tube *B* in position; *A* is a ½-in. round iron, with the hook on the lower end at *C* to engage with the eye of the eyebolt *D*, which screws into the cast-iron plug *E*.

When a leak develops in the absorber,

double-shift type where tight and loose drums are used and the hoisting is done from any number of levels. It automatically adjusts itself and so removes any chance of failure on the part of the engineer to make any adjustments.

"The stop has control of the engine at each and every hoist and at any speed, and gradually cuts off the steam supply from the main or slide valve of the engine when the cage approaches the landing or dump, and so weakens the power of the engine, the slow application of the steam brake acting at the same time. It also does away with the danger of knocking the engine to pieces by continuous 'plugging,' as it is called, which is the favorite method of stopping."

Acts at Any Speed

"Will it answer at any speed?" I inquired.

"Yes, no matter how fast or how slow," replied Hunter, "as the movement of the drum in either direction actuates the stop mechanism at a prearranged time, suitable to the hoisting conditions. The stop acts at every hoist on the main valve and does not interfere with the reversing of the engine at any time, as you might think. In fact, its action is always a positive warning to the engineer that the cage is approaching the landing, and if he is heedless of the warning by the action of the stop, the engine will be brought to a standstill before reaching the danger limit, making it necessary for him to manipulate his engine in order to reach the landing. The engineer usually has his hand on the lever in regular hoisting work, and when the lever begins to move he has warning that the cage is approaching the end of the hoist. If he fails to control the engine, because of a faulty throttle or other reasons, the stop will do it for him.

"There are cases where a speed limit is required in hoisting and provision has been made whereby it is set automatically by the stop when the increased speed limit is reached, and to automatically allow the engines to resume their normal speed again when brought under control.

Engineer Can't Go Wrong

"By the use of this stop it is absolutely impossible for the engineer to hoist up when he intends to go down, the machine having control of the engine in this respect, as the revolving disks are always operated at the danger point.

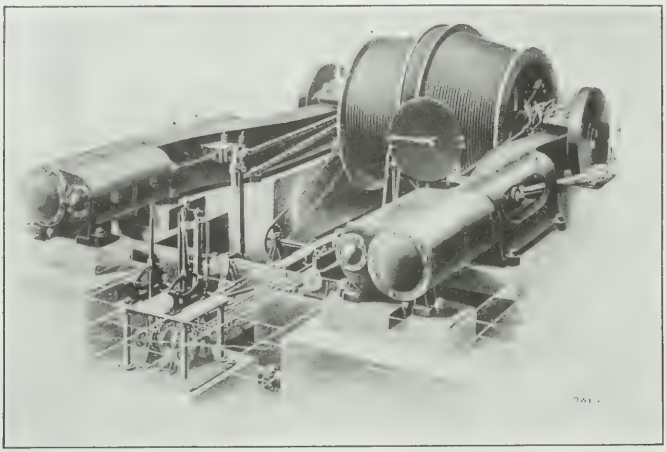


Fig. 2. Showing Arrangement of Engine Stop under Flooring of Engine Room

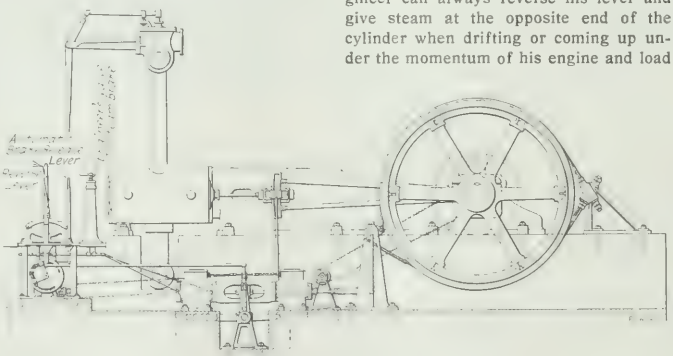


Fig. 3. Elevation of Engine, Stop and Auxiliary Steam Cylinder

"The stop is operated by a sprocket wheel and chain, which works a worm and worm gear, and is arranged as shown in this sketch." And Hunter proceeded to sketch Fig. 3.

I afterward obtained photographs of the device, which are shown in Figs. 2, 4 and 5. By referring to the illustrations, Hunter's explanation will be easily understood.

"On the ends of the wormwheel shaft is a disk having two adjustable springs which press tappets (Fig. 4) against the face of the disk. These tappets are placed at a position equal to the travel desired. The tappets and disk revolve in either direction and come in contact with the extended end of the reversing lever, which moves toward the center of the quadrant. This hooks up the links of the engine and brings the steam valve to the cutoff position, thus closing the steam ports of the engine. At the same time the brake mechanism works in unison with the cutting off of the steam. The tappets are held against the reversing lever, and it can only be operated in the opposite direction."

"You mean that the engine cannot be started to hoist again until the link motion has been changed, and the engine run in an opposite direction to the first motion of rotation?"

"Just that. It is impossible for the cage to go up when it should go down. Under this shaft there is a disk for operating this steam valve, which shuts the brake slowly and takes up the momentum of the drum before the final application of the brake. This is adjusted so as to bring the engine to a stop before the danger limit is reached at either end of the hoist in case of a runaway."

Engineer Controls the Engine

"If this stop controls the engine, as you say, and as I have seen it do, I should think that it would interfere with the engineer in controlling the engine," said I.

"It doesn't," replied Hunter. "The engineer can always reverse his lever and give steam at the opposite end of the cylinder when drifting or coming up under the momentum of his engine and load to the landing, just the same as he does with engines not equipped with these stop motions."

"Well, how about lifting the cage from the fans, after it has rested upon them?" I next inquired; "there has to be some leeway for that."

"The mechanism is adjusted so as to

allow the engineer to lift the cage from the fans, and then reverse and go down. It works equally well when dumping cages are used. As the cage nears the curved guide it gradually slows up as the travel of the engine valve is diminished, and the steam brake gradually set for the prearranged limit of the hoist. It is only necessary to throw a lever to shut off the steam supplied to the brake. If it is necessary to give a little more valve opening after the reverse lever begins to move toward the center, a special

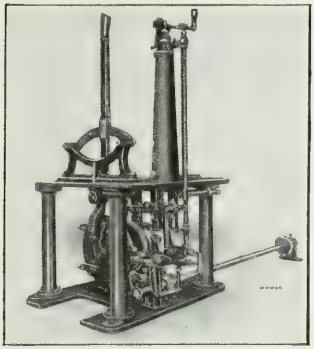


FIG. 4. DETAILS OF AUTOMATIC ENGINE STOP

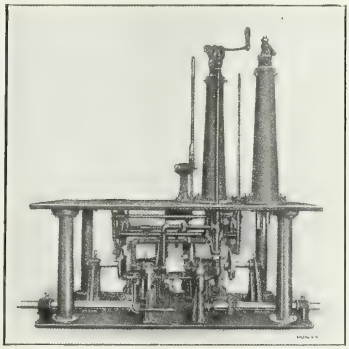


FIG. 5. STOP FOR USE WITH A NUMBER OF LEVELS

device allows the engineer to give the engine a little more steam."

"How about the cage that is nearing the bottom of the shaft?" I asked. I did not quite understand how the stretch of the rope, due to the load on the cage nearing the top of the hoist, could be taken care of and at the same time have the stop so adjusted as to take care of the empty cage at the bottom of the shaft, which had practically no stretch in the rope.

"Well," laughed Hunter, "the rope on the empty cage will be the same on both sides of the hoist, so if the rope on the loaded car is stretched more than that on the empty car, the conditions will be reversed on the next trip. For that reason the cage will always reach the bottom of the shaft at the same time the engine is stopped."

A GOOD INVESTMENT

"Of course, that is so simple I wonder I did not think of it before. It seems to me that there are so many accidents to hoisting machinery that it would be a safe investment to install a stop on every hoisting engine at the mine, whether used on shaft or slope work."

"Well, I've seen smashes that would take considerably more money to repair than an engine stop would cost, but it is a good deal like locking the stable door after the horse has been stolen. Some people do not learn by experience. They seem to think that all of the accidents will occur with the other fellow, and act surprised when something happens to their own outfit. You know some men are called 'lucky.' People have applied that term to me, but I do not consider it as luck at all; it is merely the result of forestalling accidents by removing the cause as far as possible by using safety devices, keeping the machinery in repair, and watching for weak spots and defects. One can learn a whole lot by noting the causes of accidents to others, and then looking over his own plant to see if the same condition exists there."

ANOTHER SMASH

We finally bid good-by to Jones, the engineer, and, jumping on a passing trolley, were soon back at the hotel. Picking up an evening paper, I saw the headlines, "Engine Gets Away from Engineer. Head Work Demolished, Three Men Killed." "Another instance of useless slaughter, when a simple little device would have prevented it," I whispered under my breath as I entered the elevator and went to my room.

A Modern Pumping Plant in Mexico

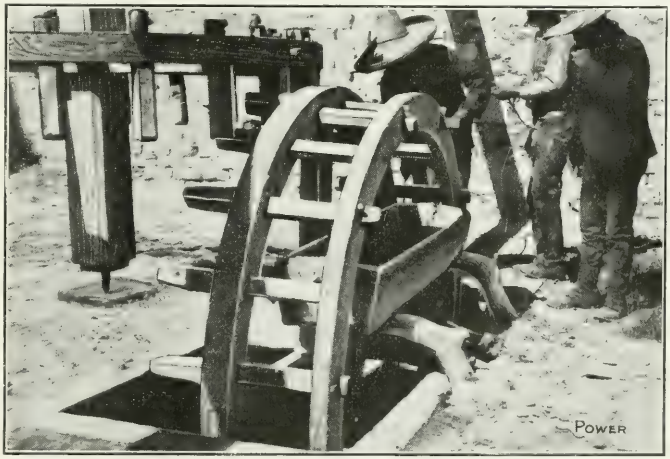
BY KIRBY THOMAS

Herewith is shown a view of a "modern pumping installation" in Mexico, which device is intended to raise water about 60 ft. Power is derived from a mule attached to a sweepstake that is direct-connected to the horizontal drive wheel. Note the "accuracy" of the meshing between the drive wheel and the vertical load carrier.

A double rope arrangement with leather buckets of about 2 gal. capacity each passes over the vertical drum wheel and empties the water when at the top of the wheel into the wooden trough, which is set under the rim of the drum, by an arrangement of the spokes on the side.

This "installation" is new, but it is an exact duplication of another pumping equipment on the same *hacienda* which bears on the rock work of the building the date 1787, and a later inscription, "remodeled 1830." The longevity of the device is thus attested to authentically.

This "modernism" in mechanics is in sight of a trunk line of railroad and near one of the large cities of the northern part of Mexico.



MODERN PUMPING PLANT IN MEXICO

Swedish water-power developments in 1911 were increased some 80,000 hp. Of this increase, 70,000 hp. was made available by privately owned plants and 10,000 hp. to the state-owned Trolhättan plant.

steam-turbine operation as a decrease in one inch of vacuum increases the steam consumption about four per cent. To maintain a high vacuum the water supply to the condensers must be ample, the tubes clean in surface condensers, the piping air-tight and the air-pump valves kept free from carbon deposits resulting from unsuitable oil, and they must work properly at all times. The chief engineer should be as intimate with the mercury column on the exhaust and a pot of suitable paint to stop air leaks as he formerly was with an indicator.

Greater power is required by all condenser auxiliaries for high vacuum; hence more attention must be given to such machinery in order to secure the best economy of the plant.

Quite a field is open for investigators to study the effect of air leakage on the maintenance of high vacuum and to develop a means whereby excessive air leakage can be easily distinguished from insufficient or ineffective water supply in condensers.

In a steam-engine plant it is one of the tasks of the chief to keep an eye constantly on his engines, watching for signs of trouble and seeing that the oilers are attending to their work properly. Steam turbines do not need such close attention; hence the engineers can give greater attention to the boiler room, where the greatest increases in economy are possible. Instead of studying indicator diagrams, the chief of a turbine plant can now busy himself with problems in furnace design, in the thermal values of coal and in high vacuum work, and in this study he can derive great assistance from careful reading of the technical press.

It is thus evident that the introduction of steam turbines within the last ten years has wrought great changes in the thoughts and activities of a large number of engineers. By adapting himself to these new conditions, the uptodate engineer is preparing for the still more radical changes in power-plant operation that seem inevitable when the superior economies of the byproduct recovery gas-producer plants and of Diesel-engine equipments are properly recognized, and the time for this recognition is not far distant, judging from the strides made recently in these fields.

A Narrow View

One of our correspondents states as his humble opinion that "No engineer in an ordinary situation paying him anywhere from twelve to eighteen dollars per week has any right to purchase apparatus such as indicators, calorimeters, etc., for the use of the firm which employs him."

On the other hand, the man who owns an indicator, a calorimeter, a gas-analysis apparatus and a few good reference books and knows how to use them, will not long be working for two or three dollars per day.

Access to an indicator, an opportunity to apply it and an intelligent study of its revelations will do more for the man than it will for the firm. This is true of the other things mentioned.

It is well for the man if they form a part of the equipment of his plant and he can gain his experience with them at his employer's expense, but if he can get access to such apparatus in no other way, he will find that his own possession and use of it will pay big returns upon the necessary investment.

The man who prefers to put in his time shining bright work because the firm will pay for the paste and furnish the rags, rather than to be analyzing flue gas with an Orsat of his own, because the firm may get some benefit from it, is likely to stay in the two-dollar-a-day class.

The Inconsistency of the "Titanic" Disaster

From an engineering point of view, the greatest inconsistency of the "Titanic" disaster was that the vessel sank with forty thousand horsepower available within herself. This power was more than enough to keep the vessel afloat until all the passengers could have been transshipped to safety.

From the time the ship struck the iceberg the engines remained idle, although there was a forty thousand-horsepower equipment, which was more than sufficient for pumping out all the water that entered the hull, doing nothing. If the engines could have been quickly connected to powerful centrifugal pumps, the inrushing water could have been pumped out fast enough to keep the vessel afloat, for forty thousand horsepower will handle a veritable flood against such a low head. As it was, the huge vessel remained afloat for about three hours after the starboard side had been torn open.

Capt. C. C. Marsh, U. S. N., is experimenting with the use of compressed air to expel the water from the compartments of a disabled ship. He, however, proposes to carry the compressed air in tanks. It is difficult to see how the various compartments can be made air-tight overhead.

"Running a Steam Turbine"

Forty-six competitors responded to our offer of a prize of fifty dollars in gold for the best article on steam-turbine operation, and their articles are now in the hands of one of the judges.

When the three judges have arrived at a decision, the award will be made and the prize article published.

The contest has brought out a mass of good material, and such points as are not adequately covered in the prize article will be presented in POWER with acknowledgment to their authors.

Standard Indicator Cocks

A great deal of unnecessary trouble is caused to the users of steam-engine indicators by the different cocks and couplings used by the several makers. It is provoking to find an engine all nicely provided with cocks and reducing motion and everything apparently ready to proceed with the taking of diagrams, only to discover that the cocks are of a different standard from one's indicators and that the proceedings must be halted until the engine can be shut down and the change made, which may involve considerable complication in the case of a side pipe and three-way cock.

It would seem that whatever little advantage there may be to a maker in maintaining an odd size taper and screw might be sacrificed to greater convenience for the user.

As far back as 1273, the use of coal in London was prohibited as a menace to public health. It had to be used a little later, however, as the forests were being destroyed. And *London Engineering*, in a recent comment on the smoke evil, naïvely adds: "It will probably remain with us for some time to come."

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Renewing Boiler Stays

While it is customary in removing defective boiler stays to tap out the hole from which the old stay was removed to a larger size to receive a larger stay, such practice, in my opinion, is injurious to the boiler plate.

In boilers of the Scotch marine type I have frequently noted that the backs of the combustion chambers were pulled out of shape, and in every instance it was found that new and larger stays had been put in to replace defective ones at the point where the plates were distorted. Assuming that the greatest ex-

IMPROVED BOILER STAY

pansion takes place at the furnace plate, the tendency will be to push out the shell, and as the furnace plate is thinner than the new and larger stays have been installed a perceptible distortion will appear. To avoid such trouble I suggest turning down the new stay to the diameter of the original one, leaving its ends larger, as shown by the accompanying illustration.

With the stays all of a uniform sectional area, the chances for rupture and distortion will be fewer, and the boilers could be subjected to more severe usage without any resultant trouble.

J. A. CAMPBELL.

Providence, R. I.

What Broke the Pistons?

Our engines are all new, having been installed less than a year ago. After they were in operation for about six months the piston in the high-pressure cylinder of the 18 and 40 by 48-in. cross-compound engine was wrecked. The accident left the bull-ring unharmed in the head-end of the cylinder. When the pieces of the piston were counted we found 103 pieces. Some of the pieces dropped into the head-end exhaust port, causing the valve to suddenly stop, thereby bending the valve stem.

The piston rod was bent in three places and a new one was required; also a new piston and exhaust valve. The cylinder head and walls were badly cut in several places. At the time of the accident the engine was running condensing, direct-connected to a 600-kw. generator, at a speed of 100 r.p.m. It seemingly ran normally until a very few seconds before the occurrence.

About two months later the 24 and 54 by 48-in. cross-compound condensing Corliss engine was partly wrecked in the same manner as the former engine, the only difference being that part of the crosshead and crank were damaged. This engine runs a rope drive at 86 r.p.m., using steam at 175 lb.

Three weeks later this engine was again similarly damaged. The engines were not overloaded.

The volume of the piping connected to the steam header is greater than the volume of the header. There is a trap on the header and one on each steam receiver.

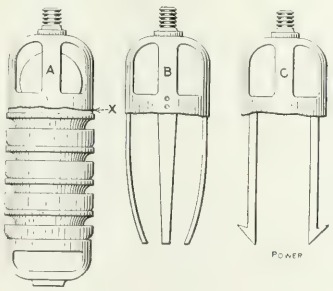
Some engineers seem to think that water accumulated in the piston until it became full and then the expansion broke it, filling the cylinder with water and the broken parts. What do POWER readers think was the cause?

A. I. HAIGHT.

Kalmazoo, Mich.

Lifting a Broken Plunger

Some time ago at the plant where I was employed the plunger on a deep-well pump broke as shown at *X* in the illustration, leaving the lower half of the plunger with part of the seat and the ball at the bottom of the pump barrel over 100 ft.



BROKEN PLUNGER AND LIFTERS

down. At *B* is shown how I used the top of the broken plunger with four strips of steel made fast to it. The strips were bent so that the ends were a trifle smaller than the ball but would spring open to pick it up.

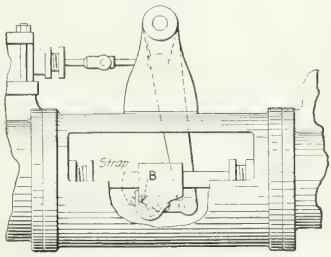
I then fastened two 18-in. pieces of steel, as shown at *C*, to the same top used to pick up the ball. These pieces were made so that when the points entered the hole in the seat they would spring together and hook onto the plunger. If other readers have a better way, I would like to hear of it.

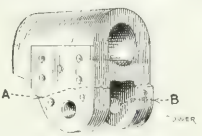
F. H. CORDNER.

Bradford, R. I.

Quick Pump Repair

While starting a duplex steam pump the crosshead broke as shown at *A* in the illustration. To get a new crosshead would have taken three or four days on account of our isolation. As the service would not admit of such a delay a ¼-in. iron plate shaped to cover the break was riveted on the crosshead together with the broken piece. The other side was broken as shown at *B*





BROKEN PUMP CROSSHEAD

and was repaired by a strap bent over the end and riveted.

The job was finished in an hour, and the pump has been in service for months without further trouble.

G. B. JOSHI.

Poona City, India.

Vacuum Caused Water-Hammer

While the effects of water-hammer are so generally known that little need be said of them, an investigation I made into the reason for an accident may be instructive.

The steam pipe to the engine had a long horizontal run to the engine where it dropped vertically to the throttle valve, which was provided with a drip to be opened when the throttle was closed. On

this occasion the attendant neglected to open the drip. Examination showed that over 22 ft. of the horizontal steam pipe was full of cold water, and that the remainder was hot as the water went back into the boiler as it formed. On opening the drip valve to drain the pipe, violent water-hammer occurred which burst the extra-heavy throttle valve.

As the pipe was 6 in. in diameter the body of water contained was great, and on opening the drip it was set in motion. As the water level in the pipe became lower, the top part of the cold pipe became exposed to the incoming hot steam which instantly condensed, forming a vacuum in the top of the pipe. The 100 lb. steam pressure then drove the water into the partial vacuum, producing great shock. As the drip valve was still open, the water returned to a level exposing more cold pipe and again producing a higher vacuum and a more severe shock. This operation was repeated each time the water returned to its level. The amount of water in the pipe became less as the travel and force of the water were greatly increased until eventually the blows, increasing in violence, burst the throttle valve. The effective force was greatest at this point, owing to the water under high velocity being suddenly stopped when it reached the valve. The reason water-hammer never happens to any extent in a vertical pipe is that the motion of the column of water is always downward and is closely followed by the steam.

Having been convinced of the correctness of the theory, the steam pipe to the engine was changed to slope toward the boiler from a point where it dropped vertically to the throttle. This allowed the water to return to the boiler and only the short vertical piece to become filled, and this could be quickly drained. If the water in the pipe had been hot a vacuum could not have been formed. The accident forcibly shows the advantage of a well drained steam pipe.

A. J. SAXE.

Chicago, Ill.

What Forms the Clinker?

In our plant there are three return-tubular boilers; No. 1 has a flat firebox and Nos. 2 and 3 have the Hawley down-draft fireboxes. The method of firing and the kind of coal are the same for all three boilers.

Much trouble has been experienced on account of clinkers forming on one side of the lower grate of No. 3 boiler, which is farthest from the stack. The rest of the grate of this and the other boilers burns very well. Can some interested reader tell me the cause of the trouble?

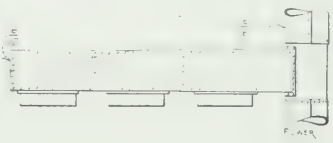
H. B. MCDOWELL.

Baltimore, Md.

Draft Troubles

In one plant the stack is very large and the breeching is of the one size throughout its entire length. In testing the draft at the main stack $1\frac{5}{16}$ in. was shown.

This condition is undoubtedly due to the breeching construction. If it was



STACK AND BREECHING

reduced as shown in the accompanying sketch, the draft for each boiler would be more uniform and the firing made much easier. The life of the boilers would also be materially lengthened.

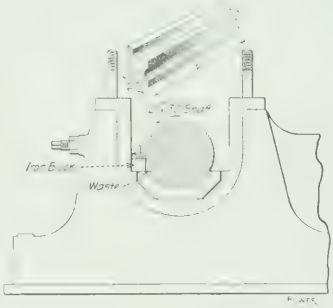
C. R. MCGAHEY.

Baltimore, Md.

Bearing Repair

In the plant in which I am employed there was a 40x60-in. engine driving a roll train, the bearing of which had become badly scored and was a continual source of anxiety and trouble.

It was out of the question to remove the shaft as there was a 70-ton flywheel to contend with, to say nothing of time lost on the mill, and it would have been folly to remetal the bearing and leave



ARRANGEMENT FOR CUTTING FACE OF SHAFT

the shaft in the condition it was. We decided to try to true it up, as there was little risk of making it worse than it was.

The cap was lifted and the quarter boxes removed; a tool used for turning sheet mill rolls, as shown in the accompanying figure, was placed in the position shown, hard grease and waste were put against the shaft below the tool to prevent chips from getting under the shaft, and a wedge was used to force the tool against the shaft. The engine was turned as slowly as possible and when enough metal had been removed, the tool was moved along to another position, and so on until the whole surface had been gone over; then fine emery cloth was used to finish it up. The shaft was then lifted enough to remove the bottom shell, the old metal was melted out and the shell replaced and remetalled.

Through an opening in the cap, three or four bars of hand Sapolio were placed on the shaft and the engine started. It was very warm for two or three hours, but by using oil freely and a little water occasionally to wash the bearing out, it was soon cooled.

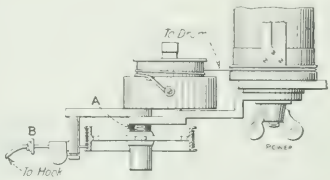
This bearing never gave any trouble afterward and was in fine condition when removed two years later to be replaced by a larger unit.

S. A. FRASER.

Middletown, Ohio.

Reducing Motion Kink

The figure shows a much used reducing motion, and the cords running to the indicator drum and to the crosshead or other moving part are marked. The cord wheel moves up and down on the threaded stem as the cord is drawn out



REDUCING MOTION WITH RUBBER INSERT

and allowed to return by the crosshead.

Ordinarily a piece of rubber or some such article is tied to the string at *B* so that, should the cord break or the hook slip, the wheel will not seat itself at *A*. A good many times the cord will snap, however, and the wheel seat itself so hard as to make the operation of loosening it highly injurious to the instrument.

The remedy is to place a small gasket —an elastic band will do—around the screw stem at *A*. No matter how hard the drum seats, the rubber will absorb so much of the energy that the drum may be readily released.

JOHN BAILEY.

Milwaukee, Wis.

Emergency Piston Repair

While employed in a sugar refinery as a night engineer, I was called on to repair a broken-off piston rod which was flush with the piston on one of our liquor pumps; the expansion packing rings and springs were also broken.

This pump had to be repaired at once and as we have no machinist at night and as it would have taken too long to

make a new rod, I filled the space between the ribs of the spider of the piston with wood blocks the thickness of the packing space and the diameter of the ribs of the spider. Then I put on two or three turns of old rubber belting the thickness of the blocks so I would have room to insert my packing. I also had the end of the piston rod tapped out for a ¾-in. cap screw. At the time of the repair we did not have any expansion rings or springs in stock, which was my reason for filling the space in the piston with wood and belting.

ROY STAHL.

Rising Sun, Ohio.

Eccentric Slipped

The engine which supplies power for a large factory was running normally when suddenly the speed decreased until the machines had to be stopped. The engineer quickly ordered the fireman to cover his fires with fresh coal and check

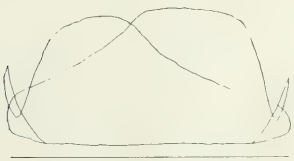


Fig. 1

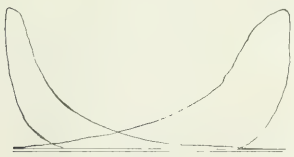


Fig. 2
Friction Load

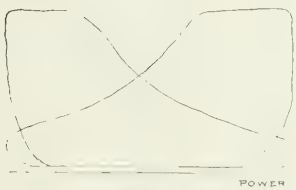


Fig. 3
Normal Load

the draft; then he shut the throttle valve, attached an indicator and secured the diagrams shown in Fig. 1.

After shutting down again, he loosened the setscrews which hold the steam eccentric in place, rolled it 8 in. in the direction that the engine ran and securely fastened it. The diagrams resulting from this adjustment are shown in Fig. 2. They show a friction load only, but when it was increased to normal and more diagrams were taken the result appears in Fig. 3.

The eccentrics on an engine should always be marked and a corresponding mark put on the crankshaft, so that if one or more are not properly lubricated, and consequently slip on the shaft, they can be quickly replaced. Failure to take this simple precaution has caused many engineers trouble and annoyance.

Every engineer in charge of anything larger or more complicated than a 15-hp. slide-valve throttling engine ought to have an indicator at hand at all times, know how to use it; and understand what a diagram tells after it is secured.

There are three interesting points about Fig. 1: It was taken from a double-eccentric engine; the exhaust eccentric is in a position to give good results; the steam eccentric is very late in performing its duty. These may easily be determined from the diagrams alone; no knowledge of the engine itself is necessary.

W. H. WAKEMAN.

New Haven, Conn.

Gear Cases

The factory was located a short distance from the freight yards of the railroad company and a spur was laid into the yards so that the heavy machines could be loaded and shipped.

To get a car into the shops so that they could be loaded with a crane necessitated the use of a large gear-driven drum over which passed a rope which was used as a capstan. The size of the large gear was about 4 ft. in diameter with a 4-in. face, going moderately slow and not covered by a shield.

As only the engineer was to operate this machine, it was assumed that no one would get hurt. He was told that many gears in the plant were uncovered, but he said they were safe and no one with average care could get caught in them.

Six months after, the engineer got his hand into these very gears, badly mutilating it.

The accident was due to the fact that the yard boss sent a helper to tell the engineer to start the machine. The man could not understand English so his boss had to talk to him in gestures. The man understood that he was to go and start the machine and pull the car into the building; he did start it up. Unfortunately the engineer was standing with his back to the direction from which the helper approached, leaning on the framework of the machine. When the helper started the machine, the engineer slipped and got his hand into the gears. Of course, after this accident all conspicuously exposed gears were carefully covered.

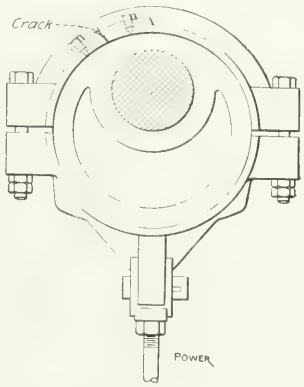
This is an actual occurrence and clearly shows the great negligence on the part of men in charge of factories, as well as machine designers. There are laws prohibiting the use of uncovered gears, projecting keys on shafts and projecting setscrews on pulleys, etc., but they are inadequately enforced.

R. FABRICE.

Brooklyn, N. Y.

Eccentric Repair

The accompanying illustration shows an emergency repair job on an eccentric strap. A piece of ¾x2-in. flat iron, 9 in. long, was shaped over the eccentric strap. The broken strap and the iron were then drilled for ¾-in. tap bolts. Care was taken to have the bolts pull against one another as shown.



BROKEN ECCENTRIC STRAP

The piece of iron was then heated red hot and bolted to the strap, and water was thrown over it. The aim was to take advantage of the contraction of the 9-in. piece to pull the broken straps together.

This repair served its purpose for several weeks before a new strap arrived.

A. POHLMAN.

Brooklyn, N. Y.

Bends for Blowoff Pipe

Much has been said about the value of bends on steam and high-pressure water lines. The blowoff line seems to have been forgotten.

Where the feed water leads to the formation of scale, the blowoff line often becomes plugged with the loose matter, causing much trouble. By installing bends in the line instead of ells, particularly near the boiler, much labor and time may be saved.

CHARLES G. FENWICK.

Wapella, Sask., Canada.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

A Narrow View

In answer to Frank Martin's question in the Apr. 16 issue, in my humble opinion, no engineer in an ordinary situation paying him anywhere from $12 to $18 per week has any right to purchase apparatus such as indicators, colorimeters, etc., for the use of the firm which employs him. If he is chief in a large plant and drawing several thousand dollars per year, the case is different and he should have them.

If the engineer in the first case mentioned is unmarried or can spare the money, and wants to learn how to use such instruments, then, too, the case is different.

An engineer who understands how to use these instruments and is employed by a wealthy concern which is too penurious to buy them, is an easy mark if he puts out his hard-earned dollars for machines for his employer's use. It is all right to say that an engineer should get these things for the sake of his own reputation, so that he can obtain and preserve a set of records showing exactly what the plant is doing, etc., but I venture to assert that the men who write such letters are the last ones themselves to do anything of the kind.

Talk is cheap, and ninety-nine out of a hundred engineers will refuse to spend a couple of hundred dollars for a set of instruments to increase a thankless employer's dividends, and in ninety-eight of the ninety-nine cases the engineer is right. Possibly in one case in a hundred the employer would make things right with his engineer after he saw the great advantage of having them in the plant, but the remaining ones would take it as a matter of course, and neither thank nor compensate the engineer for his outlay.

JOHN STRONG.

London Junction, Ont.

Power Plant Operating Costs

I was very much interested in the editorial under the heading, "Power Plant Operating Costs," in the Apr. 16 issue. Perhaps an experience I once had will be of interest. I was engaged as assistant engineer in a paper mill; it had a battery of five boilers, of a total of 700 hp. but, as was said in the editorial, there was no one taking any interest in the power end of the plant.

The chief engineer was called on to do every odd job, even to repairing holes in the roof. He told me that he did not get any time to look after the plant, and wanted me to see if I could make any improvement. The first day I was there the fireman came into the engine room about 10 o'clock and said I would have to shut down a couple of machines, as he was about to begin cleaning fires. To my surprise, I found that this had been the practice for quite a long time.

The water for the boilers was pumped from the river by a three-plunger pump through a home-made heater made of 4-in. pipe lengths inside of 6-in. pipe; the 4-in. pipe was connected with the pump line and the 6-in. line carried exhaust steam. The exhaust steam was first run through the driers of the paper machines and by the time it reached the heater it was nearly all condensed. From the heater it went into the sewer; the surplus water was taken care of by a relief valve which was connected to the second set of pipes. Thus all of the water had to go through one side of the heater before it reached the relief valve; about 90 deg. F. was the highest temperature we could get.

I put a relief valve in the line near the pump, which raised the feed-water temperature to 132 deg. The engines were piped for an indicator, but the firm did not have such an instrument. I persuaded a friend to lend me his, and if I had been a subscriber to POWER at that time I could have shown some diagrams that would have surprised its readers. On taking the head off the engine that showed the poorest diagram, we found one piston ring broken into a dozen pieces; it had been broken so long that the pieces were rounded on the edges. When new rings were put in and the valves properly set on all the engines, there was no trouble in keeping steam even while cleaning the fires.

The manager was interested right away, and told the chief to go ahead and put the steam end in shape. He installed a vacuum system of heating the driers, also a modern feed-water heater, with oil separators in the exhaust line so that the water of condensation was used for boiler feed, which then entered the boilers at 210 deg., and reduced the back pressure on the engines from 8 to 3 lb. As one boiler needed retubing, it was then cut out, and on taking out the old tubes we found 940 lb. of scale in it. That was the worst boiler in the plant, but all were badly scaled.

A rotary tube cleaner was purchased and also shaking grates. The plant now uses but four of the five boilers, it has plenty of steam, and burns from 28 to 32 tons of coal, where it formerly burned from 48 to 60 tons. Before the change it was almost impossible to keep the firemen, but the present crew has been with them over two years.

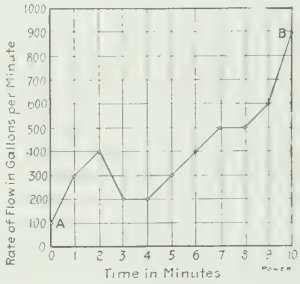
It seems queer to me that owners who are considered shrewd business men will allow such losses, but there are a great many plants in which conditions are equally as bad.

U. C. WOOD.

Copenhagen, N. Y.

The Arithmetical Mean

Prof. Smallwood illustrates one of his points in his article under the above title in the Mar. 12 issue by the consideration of a series of determinations made for the quantity of water discharged through a pipe line containing a venturi meter tube connected to a manometer. This illustration requires the use of a manometer scale graduated in inches difference of water or mercury levels.



FLOW CURVE

In laboratory work, a scale so graduated would be proper since students should be required to make their own calculations from the theoretical formula expressing the relation between differential pressures and rates of flow; in practice, however, the scale of a measuring instrument is usually graduated directly in quantity or rate. For instance, assume that a 10-minute test with a venturi meter having the scale graduated in "gallons per minute" gave the results shown by the accompanying curve,

the first reading of 100 gal. per minute being taken at *A* and the last reading of 900 gal. per minute at *B*. Between *A* and *B* 10 intervals of time of one minute each have elapsed. If we average the readings by the usual method for such a test, we obtain the following:

Time	Rate
0	100
1	300
2	400
3	200
4	200
5	300
6	400
7	500
8	500
9	600
10	900
	11)4,400
	400 average rate

To correctly average, however, we should take the average of each interval, add the results together, and then take the average of the total as follows:

Interval	Average rate
0- 1	200
1- 2	350
2- 3	300
3- 4	200
4- 5	250
5- 6	350
6- 7	450
7- 8	500
8- 9	550
9-10	750
	10)3,900
	390 average rate

The first method then shows an error of + 2.6 per cent., which might be of material importance in the test involved. This is a point which Mr. Smallwood does not bring out in his article.

Instead of averaging each interval as above, the following rule may be used for obtaining the correct average:

To one-half the sum of the first and last readings, add the sum of the intermediate readings and divide by the number of intervals.

Thus in the above test the correct average is:

$$\frac{\frac{900 + 100}{2} + 3400}{10} = 390$$

CHARLES G. RICHARDSON.

Providence, R. I.

Troublesome Feed Pump

In regard to A. J. Berlin's trouble with his feed pump, as related in the Apr. 2 issue, I think the cause of the disk shifting was that when he shut the pump down the valve disk would settle back, either by the pressure being off the feed line or the pressure caused by a leaky check valve; when he would start the pump, the vibration and direction of flow of the water would jar it onto its seat; this would be possible.

Something similar happened to one of our boilers some time ago, only the disk of the feed-water regulator unscrewed from of the stem. The first trouble was reported by the water tender of my shift; he claimed that the check was stuck, but by listening to what little water was passing through the regulator I came to the conclusion that this was the location of the trouble. After closing the feed valves, I took off the bonnet of the feed-water regulator and also took out the disk on account of the threads being worn, and fed that boiler by hand until we cut it out for cleaning, when we repaired the regulator.

I think the closing of the valve by the disk blew out the gasket between decks of his pump unless he had a number of boilers on the line as we did; then it ought not to have blown the gasket. Our pumps are provided with governors.

ROY STAHL.

Rising Sun, Ohio.

Temperatures in Engine and Boiler Rooms

Mr. Westerfield's letter under the above title in the Mar. 5 issue is interesting; but economy does not always result from keeping the windows closed, as the following cases will show.

In a flour-mill plant one of the generators would get so hot that we were often compelled to shut down and switch over on the city service. It was suggested that the window directly opposite the machine be left open. After doing this and letting the cold air blow on it, we had no further trouble.

In a central-station plant we were troubled with an overloaded alternator. This machine would run very hot and spark greatly, and also require an abnormal amount of exciter voltage to keep up that of the machine. Cold outside air was allowed to blow in through a window and the trouble disappeared.

All the piping was well covered, so I believe the losses incurred by more rapid radiation were more than compensated for by the increased efficiency of the generators.

M. A. JENSEN.

Nebraska City, Neb.

Centrifugal Pump Troubles

Milton Baker, in the issue of Mar. 26, presents a question of centrifugal-pump installation. The conditions as stated are that 2500 gal. of water containing some 8 per cent. of solids are pumped per minute through a 10-in pipe line 2000 ft. long and lifted to a height of about 70 ft. The troubles are caused by the occasional separation of the moving column of liquid, particularly when starting up or shutting down. The three pumps used are so spaced along the pipe line as to divide the total head about equally between them.

While the size used would be adequate for a short pipe line, it seems obvious that a larger size, say, 12 in., would have been far more advantageous. The velocity through a 10-in. pipe discharging 2500 gal. per minute would be about 10.2 ft. per second, corresponding to a velocity head of about 2 ft. The same quantity would pass through a 12-in. pipe with a velocity of 7 ft. per second, the velocity head being less than 1 ft.

In the issue of Apr. 4, 1911, page 523, it may be seen that the diagram showing the frictional head in feet per 1000 ft. of pipe, for the usual pipe sizes and for various quantities of water, gives, for 2500 gal. per minute, passing through a 10-in. pipe, a frictional head of 42 ft., which in this case, for 2000 ft. of pipe line, gives 84 ft.

The total head against which the pumps must work, neglecting the 8 per cent. solids which the water contains, is then 70 + 84 + 2 ft. velocity head = 156 ft.

The water horsepower is

$$\frac{2500 \times 156}{3960} = 98.5$$

The constant 3960 is used for clear water.

Assuming an efficiency of 55 per cent. for the type of pump used, the required brake horsepower is

$$\frac{98.5}{0.55} = 179$$

For a 12-in. line the diagram gives a frictional head of 16½ ft. per 1000 ft., or a total of 33 ft.

The total head would then be 70 + 33 + 1 ft. velocity head = 104 ft. The water horsepower equals

$$\frac{2500 \times 104}{3600} = 65.65$$

Assuming 55 per cent. efficiency, the brake horsepower is

$$\frac{65.65}{0.55} = 119.4$$

The difference in brake horsepower is 179 — 119.4 = 59.6, say, 60.

With a 12-in. line, only two pumps are required, since

$$\frac{156}{3} = 52 \text{ ft.}$$

head for each pump, and 52 × 2 = 104 ft., which is precisely the head calculated as required for the 12-in. pipe. The great economy to be gained by using a 12-in. line is now evident.

To remedy the present trouble with the least expense I suggest putting the three 10-in. pumps now used, at the No. 1 station, and connecting them in series; that is, the first pump discharging directly into the suction of the second, the second discharging directly into the third, and this latter discharging into the line. In this way it would not be necessary to install air chambers, check valves, reservoirs or sump holes, and the priming, starting and stopping would all be done at one single station and would be under perfect control.

If the work is to extend for a long period, say over a year, it might be well to investigate into the question of replacing the present 10-in. line by a larger size one.

ALBERT E. GUY.

Pittsburg, Penn.

Inquiries of General Interest

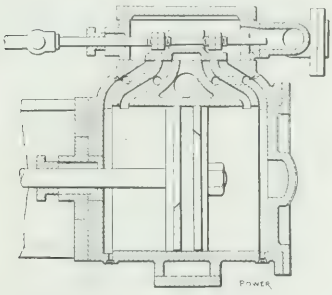
Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Cushion Valves

What are the valves located at each end of the cylinder on the outside of the steam cylinders of a duplex pump?

G. A. W.

They are cushion valves, and are located in a passage connecting the steam port with the exhaust port at each end of the cylinder. Referring to the illustration, when the piston covers the exhaust port near the end of the stroke, the piston is brought to rest, without any shock by compressing the small amount of steam left in the cylinder after the exhaust port is closed. The compression can be regulated by adjusting the compression or cushion valves, so as to permit the escape of more or less of the compressed steam into the exhaust port.



SECTION THROUGH CYLINDER

Height of a Horizontal Tubular Boiler over the Grate

What should be the distance from the grate to the bottom of the shell, the top of the bridge-wall from the bottom of the shell, and the back end from the rear wall, of a horizontal tubular boiler?

R. F. J.

The distance from the top of the grate to the bottom of the boiler should be about 24 in. for grates 4 ft. long, this distance increasing in proportion to the length of the grate. This applies to grates using anthracite coal only; for bituminous coal the distance should be increased from 30 to 36 in.

The distance from the back end to the rear walls should be about 16 in. for boilers less than 58 in. in diameter, and from 18 to 24 in. for larger boilers.

Usually 9 in. is the distance from the bridge-wall to the bottom of the boiler, for boilers up to 60 in., and 10 in. for larger sizes.

Westinghouse-Parsons Steam-Turbine Governor

How is the speed of a Westinghouse-Parsons turbine controlled?

J. M. M.

Steam enters the turbine through a poppet valve, controlled by the governor. At light loads the valve opens for short periods, remaining closed for the greater part of the time. As the load increases the valve remains open longer, until when full pressure is continually maintained in the high-pressure end of the turbine the valve merely vibrates without sensibly affecting the pressure of the steam. If the load is still further increased, an auxiliary valve begins to open and admits steam directly into the lower stages of the turbine.

Boiler Scale Solvent

Have molasses and tanbark any value as boiler-scale solvents?

J. K.

They will act by virtue of the acetic and tannic acid they contain. They may act on the scale, but they corrode the metal of the boiler.

Water Pail Forge

How is a "water-pail" forge made?

B. C. C.

The method of heating with a water-pail forge consists of plunging the metal to be heated beneath the surface of a conducting liquid; the metal should be connected to the negative pole of a continuous source of electric current. The vessel containing the liquid is provided with a lead lining, which is connected to the positive pole. To render the liquid conducting, a salt, such as sal soda, is dissolved in water to a specific gravity of 1.2, and to every 10 gal. of solution 5 lb. of borax are added.

Weight of the Governor Balls

Will changing the weight of the balls of a fly-ball governor affect the action of the governor?

G. McB.

Theoretically, the action of the governor is independent of the weight of the balls; practically, there is considerable friction in the mechanism of the governor, and the balls must have weight enough to overcome it.

Duty of Pumping Engines

What is the definition of "duty," as applied to pumping engines?

P. K. M.

Duty may be expressed as the number of foot-pounds of work obtained in the pump cylinders per 1,000,000 B.t.u. furnished to the engine by the boiler. Another definition is the number of foot-pounds of work done in the pump cylinder per 100 lb. of coal burned in the boiler; this, however, includes the boiler efficiency and the heat value of the coal.

Fan Capacity

How many cubic feet of air per minute must a fan furnish to a battery of boilers having a total capacity of 450 hp., assuming that 1 lb. of coal evaporates 8 lb. of water, and that 1 lb. of coal requires 230 cu.ft. of air for its combustion?

B. O. T.

Assuming that the boiler evaporates 30 lb. of water per horsepower per hour, the water evaporated per hour by the boilers would be

$$450 \times 30 = 13{,}500 \text{ lb.}$$

Since 8 lb. of water are evaporated per pound of coal

$$\frac{13{,}500}{8} = 1687.5 \text{ lb. per hr.}$$

or

$$\frac{1687.5}{60} = 28.12 \text{ lb. per min.}$$

The air required by the fan would be

$$28.12 \times 230 = 6467.6 \text{ cu.ft. per min.}$$

Loss of Current through Grounds

Does an electric circuit lose any current when one side of the system is grounded?

W. H.

No, if only one side of the system is grounded.

"Duff" Coal

What is "duff" coal?

S. A. G.

"Duff," according to the *Standard Dictionary*, means "small or fine coal," and is used to define washed bituminous slack.

The Power Show at Boston

A great success was the general verdict, not only in the number and quality of exhibits but also in the attendance. Engineers, mechanics and men prominent in the field from all over New England were there and were as enthusiastic about the show as the exhibitors were over the results of their attendance. The New England Association of Engineers, which made all arrangements and conducted its first power show during the week of Apr. 22-27 in conjunction with the third annual exhibition of textile machinery, is to be congratulated on its enterprise, and it is small wonder that it was unanimously decided to make the show an annual event.

The exhibition covered two large floors and the gallery of the Mechanics Building. The entire basement was devoted to power-plant exhibits and on the floor above were to be seen all kinds and types of textile machinery in operation, humidifiers and air-conditioning plants. In the gallery were samples of finished products and even made-up garments were exhibited here by some of Boston's leading retail merchants.

On Monday afternoon, at 2 p.m., the show was opened to the public, and during the evening between 6:15 and 7:30 the Commercial Engineers held a dinner which was attended by about 125 members and guests. The power show set aside Tuesday as engineers' Blue Room Club day and a large number of the members was in attendance. Wednesday was N. A. S. E. day for New England engineers. The National Association of Cotton Manufacturers also opened its annual convention in Paul Revere Hall, which was continued on Thursday.

A number of interesting papers were presented, and the following, which may be of interest to POWER readers, will be presented in later issues: "The Interpretation of Water Rights in Connection with Water Power," by Richard A. Hale; "Steam Plant Efficiency in Textile Mills," by R. L. Foster, and "Transmission of Power by Ropes," by Edwin Kenyon.

On Friday the Master Mechanics Association of America held its first convention. Three papers were read: one by John S. Schumaker on "The Attitude of Employer and Employee toward Scientific Management"; another by Edward A. Uehling on "Steam Boiler Efficiency," and the third was Mr. Foster's paper on "Steam Plant Efficiency in Textile Mills," which had been previously presented at the Cotton Manufacturers' convention. The two papers last named will be given early attention in these columns.

Saturday was the closing day of the show and was featured by a mid-day luncheon under the auspices of the Master Mechanics Association.

All of the exhibits were of interest, but a certain few, due to their arrangement or some distinctive feature, seemed to attract the visitors. Upon entering the hall the first booth to catch the eye was that of the Cork Insert Co., of Boston, in which were displayed a number of iron, wood, steel and paper pulleys with cork inserts. All were of large diameter and the background was made up of brake facings and "frictions" and "tensions" cut to suit all uses.

Hess-Bright Manufacturing Co. had an attractive exhibit the feature of which was a background case brilliantly illuminated and containing about 1500 bearings of different size and style of thrust, including annular bearings.

An optical illusion in the form of a series of chain drives operating behind a rotating, slotted disk was exhibited by the Link Belt Co. By looking through the disk, two of the chains were seemingly at a standstill, one appeared to move slightly in a forward direction and a fourth in a direction opposite to its travel. The object of the device was to illustrate the action of the chain on the sprockets.

The new spiro turbine of the Buffalo Forge Co., exhibited in connection with a complete air-conditioning apparatus for a two-story mill designed by the Carrier Air Conditioning Co. of New York, was a novelty.

Those interested in CO_2 recorders dwelt around the space occupied by B. L. Ames. Two Precision instruments were attached to the boilers of the building and were kept in constant operation. One of the machines had a 60-day chart on which were recorded both draft and the percentage of CO_2. In the same booth a Monarch steam soot-remover for water-tube boilers and superheaters was on exhibition and also a Climax smoke preventer with an improvement to eliminate all objectionable noise.

Not far away the Uehling Instrument Co. had one of its standard CO_2 and temperature-recording machines which was also attached to the boilers and in operation.

Austen & Doten, distributors for the National Tube Co., had a remarkable table made up entirely of samples of Shelby seamless steel tubing. It contained 3000 pieces and weighed 1700 lb. Kewanee specialties were, of course, in evidence, and an interesting feature was a testing machine showing how the unions are tested under water with compressed air.

John B. Perkins Co. showed a variety of products from the companies represented. These included Sarco traps and a CO_2 recorder, pump models, a new Perkins damper regulator, Alphons Custodis brick and particularly a special demonstrating model of a Hewes & Phillips Corliss engine with the new Franklin releasing valve gear. The cylinder, which was 10x24 in., was cut in two lengthwise and covered with a glass plate in order to show clearly the operation of the piston and valves under normal working conditions.

One of the features of the show was a 500-hp. Cochrane open heater, equipped with a V-notch and Lea recorder. A small circulating pump kept up a constant flow of water, and portholes in the wall permitted an inspection of the interior.

Immediately back of this exhibit, in the booth of the Robb Engineering Co., was a full-size return-tubular boiler front equipped with a 6x6-ft. Macdonald shaking grate. Test pieces of metal and a section of the joints, showing the style of riveting, were also in evidence.

At the booth of the Chapman Valve Manufacturing Co., the crowd never tired of watching the working of two gate valves, one electrically operated and the other hydraulically.

Another attraction was the immense No. 20 E Koerting Universal injector, exhibited by the Schütte & Koerting Co. It had capacity to supply 2500 boiler horsepower at 150 lb. working pressure. An electrically controlled engine stop succeeded in startling some of the lady visitors every time it was operated. Film specialties and other items made up the exhibit.

The Holyoke Machine Co. showed running exhibits of its new "Improved" hydraulic waterwheel governors of horizontal and vertical types, and also of its mechanical governor. The new governors created a great deal of interest, and were carefully compared with the Lombard governor, which, with its complete oil and air outfit, was exhibited in another booth in connection with a vertical wicket gate wheel, made by the S. Morgan Smith Co.

Perhaps the most conspicuous exhibit in the show was that of the Johns-Manville Co. With its various asbestos products neatly arranged under a portico covered with Transite shingles and the supporting columns twined with wistaria, the effect was most pleasing. A feature was the exhibit of "J. & M." sectional conduit and sponge filling for underground steam mains. Linolights brilliantly illuminated the booth.

To illustrate the difference in friction between the ordinary babbitted bearing and Sells roller bearings, the Grant Nail & Supply Co. exhibited a number of American iron pulleys and Gilbert wooden

pulleys, equipped with both types of bearing. A feature attracting considerable interest was a jackshaft, equipped with three pulleys running on roller bearings and driven by a small string.

The balance of the exhibits, many of which were just as attractive and interesting as those previously described, may well be classed under general headings covering the principal product exhibited.

Valves

There was a great display of valves of all types and sizes. The Ashton Valve Co. had a very attractive collection of its standard types, and a display of gages and sanitary drinking fountain, through which was dispensed "Adam's ale" to all comers.

The American Steam Gauge & Valve Manufacturing Co. was featuring the American H_2O grease-extracting feed-water filter and a new line of globe valves. A pyramid of brass safety valves, relief valves and whistles made a neat display.

The Lunkenheimer booth was attractive with its display of high-pressure steam valves, lubricators, grease cups and a special nonreturn stop valve.

Jenkins Bros., besides their usual line of valves and mechanical rubber goods, had a special exhibit of gate valves with iron and brass bodies.

Bashlin valves and faucets were exhibited by the Hyland Manufacturing Co.

Braman, Dow & Co., representing the William Powell Co., had a full line of "White Star" valves, globe, gate, blowoff and check, and an exhibit of the "ready" throttle valve.

Modulation-system valves and appliances for vacuum heating and air washer display parts formed the exhibit of Warren Webster & Co.

Monarch gate valves for all kinds of service and the Rothchild rotary gate valve were displayed by Mr. Hosley, New England agent for the Monarch Valve & Manufacturing Co.

Pumps

The booth of the International Steam Pump Co. contained a combination exhibit of Blake & Knowles, Clayton and Deane apparatus. The company first named was showing a case filled with working models of its various types of pumps and one of its new single pumps for 250 lb. pressure. The Clayton exhibit was a small compressor for garage work. Deane triplex pumps, a 6-in. power weld head and a section of a single boiler-feed pump completed the exhibit.

The Goulds Manufacturing Co. showed a number of power pumps, the features of the booth being a double-suction, 4-in. centrifugal pump, and a centrifugal small enough to be carried around in a coat pocket, with a capacity of 30 gal. per minute.

The American steam pump was exhibited in the booth of J. B. Perkins, previously mentioned.

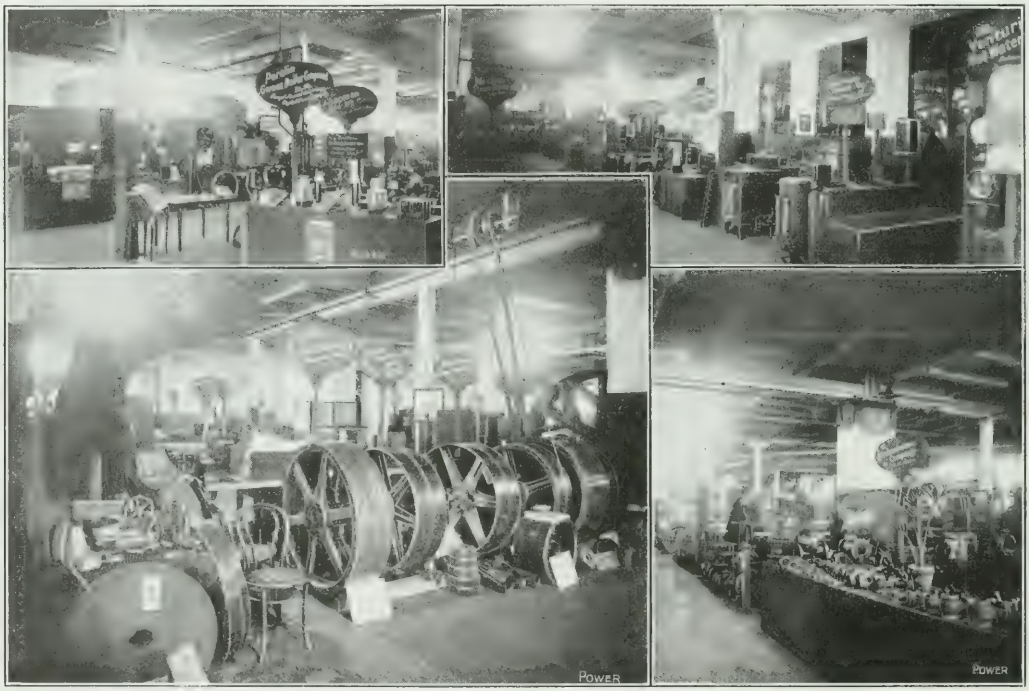
Boiler Accessories

A number of grates were on exhibition. The Burke Engineering Co. had a 6x5-ft. Neemes grate, the Canton Grate Co. displayed a 4x4-ft. grate of its make and a model, half size, was the exhibit of the Perfection Grate Co. H. F. Morse exhibited a full-size Cyclone grate, mounted in a brick setting.

The McLeod & Henry Co. was exhibiting its boiler-door arches and jambs, firebox blocks, back-combustion chamber and a model of a horizontal tubular boiler, showing the arches and firebox lining.

A working model of an economizer, a "Positivflo" heater section and a planing-mill exhauster comprised the exhibit of the Green Fuel Economizer Co.

A Richardson coal scale, weighing rice for convenience, was an interesting machine to watch, and an attractive booth was that of the Pennsylvania Flexible Metallic Tubing Co. The exhibit consisted of hose of various sizes, spirally wound with copper, including a special hose designed for blowing boiler tubes.



Some of the Exhibits at the Boston Power Show

Steam Specialties

The Nashua Machine Co. had a working exhibit of the new Bundy trap, which now has a round body and has been simplified by doing away with the trunnion joints and the curved tube within. The working exhibit consisted of a receiving tank, lifting and return traps, operated by compressed air.

High- and low-pressure traps, a display of seamless copper floats and improved safety water columns were put on exhibition by the Wright Manufacturing Co., and in the same booth sections of Austin steam and oil separators were to be seen.

A. W. Barnes had a varied exhibit, consisting of Sterling float traps, made by the Templeton Manufacturing Co., a Hart force sight-feed lubricator and the Sherwood specialties, also literature on the American Ball engine and Mackie heaters.

Exhibits of the Tillotson Humidifier Co. were a humidifier and yarn steamer in full operation, and a line of ideal traps, among which was a new low-pressure trap with a 2½-in. outlet for handling large amounts of condensation.

G. P. Anderson, New England representative, displayed a line of the latest Rochester automatic lubricators, made by Greene, Tweed & Co., the Kieley specialties and American metal hose.

Another line, exhibited by the Nightingale & Childs Co., was the Swartwout steam specialties. Asbestos of varied finish added to the appearance of the booth.

The Mason Regulator Co. showed its full line of pressure-reducing valves, balanced valves of piston and beveled seated types, a pump speed governor and a hydraulic damper regulator.

The Elliot products at the show were grease extractors and filters, the T. W. regulator, float traps, oil separators, water alarms and the Faber blowoff valve. The features were a twin strainer and a new back pressure or relief valve, 12 in. in diameter.

Boiler-tube Cleaners and Soot Blowers

A number of well known cleaners were represented at the show. The Diamond Power & Specialty Co. showed five different soot blowers, featuring, however, the horizontal tubular and Manning types. The Liberty Manufacturing Co. called attention to its tube cleaners by raucous blasts from one of the motors. The Patterson Lubricating Co. showed the Lagonda line of cleaners, multiple strainer and reseating machine, and its own P. L. C. packing, while the Dean cleaners, as well as an improved gas analyzer for CO_2, CO and O, were placed in evidence by the William B. Pierce Co.

The Charles A. Claflin Co. exhibited its automatic and continuous-blast blowers for removing soot from fire-tube boilers, and various patterns of "Sure-Hold" adjustable clamp steam hose fittings.

Packings

Sheet, fibrous and metallic packings were well represented by the various brands of the following firms: France Packing Co., represented by J. Henry Blanchard; A. W. Chesterton Co.; Greene, Tweed & Co.; Peerless Rubber Manufacturing Co., whose "Rainbow" packing and belting, as well as the product of the Eureka Fire Hose Manufacturing Co., were displayed in a large booth by the Enterprise Rubber Co., of Boston; the Garlock Packing Co. and the Boston Belting Co., which had a full line of mechanical rubber goods.

Power-transmission Appliances

In this line the Reeves Pulley Co. demonstrated its variable-speed transmission, and, in addition, a number of wood split pulleys and clutches.

William Sellers & Co., Inc., had a large exhibit of various types of belt drive, illustrating its different products of manufacture; pulleys, hangers, shafting, binder frames, bicycle drives, etc.

Cotton transmission rope with wire center and screw couplings to avoid splicing was tested in a machine for the purpose in the booth of the Sampson Cordage Works. Several types of rope drives were also kept in motion.

An 84-in. steel pulley, with a 38-in. face, which had been in service for four years, was the feature of the Oneida Steel Pulley Co.'s booth.

The American Tool & Machine Co. was displaying steel pulleys, centrifugal oil separators and shaft hangers.

Several sizes of Samson friction clutches were on exhibition in the booth of George L. Fairbanks & Son, and the Dodge Manufacturing Co. showed its Orton and Dodge clutches, in addition to its several distinctive types of split pulley.

A wigwam, made up of Indian tan lace leather and an exhibit of Victor-Balata and Phœnix belting were offered for inspection by the New York Leather Belting Co., and in another space the Cling-Surface Co. was operating a testing outfit, to show the difference in pulling capacity between a belt under high tension and one treated with Cling Surface.

Oils, Filters and Lubricators

Lubricating oils for all purposes were in great abundance. Some firms had barrels of it and others sample phials, and in most cases cans of grease were included in the exhibit. The following firms were represented at the show: Albany Lubricating Co., American Oil Co., the Texas Co., Keystone Lubricating Co., Borne Scrymer Co. and the Underhay Oil Co.

The Richardson Phenix Co. had on exhibition one of the No. 2 Richardson individual automatic oiling systems, a Phenix type oiling system, a model M force-feed lubricator and a line of oiling apparatus.

S. F. Bowser & Co. featured a very complete and compact oil-filtration and circulating system, oil-can fillers for mill use and a number of other specialties. The Economy Lubricating Co., of Boston, showed the Economy and Lunkenheimer grease cups.

Force-feed lubricators, single, double, triple and eighteen-feed, made an attractive exhibit for the Hills-McCanna Co., Inc. An interesting feature was one of the old pop-bottle lubricators dating back to 1873.

The International Acheson Graphite Co. drew attention to its graphite products with an illuminated model of a furnace in which graphite is made.

Instruments, Gages and Meters

Apparatus of this kind was not lacking at the show. The Schaeffer & Budenberg Manufacturing Co. had an extensive and varied display of indicating and recording gages, tachometers, calorimeters and steam-engine indicators. Columbia recorders and "reform" mercury thermometers made up in gage form were the features attracting special attention.

A Venturi hot-water and steam meter with a quantity indicator dial, a recording chart and counter was the attraction offered by the Builders Iron Foundry, of Providence. The meter had a capacity up to 1500 boiler horsepower.

An Emerson fuel calorimeter and thermoelectric pyrometer were exhibited by the Emerson Apparatus Co. in conjunction with a textile conditioning oven and a small model of the Kilgour boiler setting.

The Standard Engineering Co. had a varied exhibit which included an Avery coal scale, a Thwing pyrometer and recording meters from the Industrial Instrument Co.

The Hohman & Maurer division of the Taylor Instrument Co. showed a varied line of meters, thermometers and gages, including a hygrodeik for determining relative humidity.

Miscellaneous

Due to their size and the inconvenience of exhibiting large units, prime movers were not numerous at the show. The Brown Engine Co. had a 11x30-in. cylinder of its latest model, also the crosshead and governor. The Terry Steam Turbine Co. was operating a 15-kw. turbine direct-connected to a Crocker-Wheeler generator, and the Allis-Chalmers Co. exhibited a turbine in section in a large booth outlined by a number of its standard motors.

The General Electric Co. featured its cloth pinions, an ozonator and a variety of Mazda lamps.

Unions, flanges and pipe-fitting specialties were featured by the Jefferson

Union Co. The Auto Force air pump or ventilator could be seen from all quarters of the hall.

Engine stops, mechanically and electrically operated, an electrical pilot valve, a damper regulator and a vacuum breaker wired up in connection with the electrical stop drew attention to the booth of the Locke Regulator Co.

The Penberthy Injector Co. exhibited its auto-positive injector, the "XL" 96 ejector in several sizes and a line of oil and grease cups for stationary and automobile use. In the same booth the McCord Manufacturing Co. was showing its McKim gaskets and force-feed lubricators.

The large copper rotor of a 48-in. fan for handling steam and acid fumes attracted visitors to the booth of the Massachusetts Fan Co., which was also exhibiting a Davidson fan for general ventilation, the rotor of a squirrel-cage fan, a heater coil with internal bleeder and a 30-in. planing-mill exhauster.

Perolin, the new German boiler compound, and "Skookum" packing made by the Bowers Rubber Works, of San Francisco, were featured by the Eagle Oil & Supply Co., and in the near vicinity P. H. Hogan, New England manager of the Dearborn Drug & Chemical Works, was kept busy spraying "boiler compound" on visiting ladies and distributing literature on the treatment of boiler water.

Boiler Inspectors Hold Annual Banquet

On the evening of Apr. 23, in the American House, Boston, the American Steam Boiler Inspectors held their third annual banquet and election of officers. The election took place first and resulted as follows: President, M. S. King; vice-president, W. O. Young; secretary, A. R. Chambers; treasurer, Adam Oldfield; executive committee, J. F. Molloy, H. Van Ormer, C. D. Noyes, T. G. Ranton and James MacDonald.

About 70 members and guests sat at table and during the coffee and cigar period were addressed by a number of speakers.

W. H. Hamilton, of the Lukens Steel & Iron Co., told how openhearth steel was made at Coatesville, and F. N. Speller, of the National Tube Co., spoke on spellerized boiler tubes. His talk first dwelt on the subject of corrosion, which, due to its complicated nature, had only been recently understood. Iron will not corrode in dry air nor in water free from air. It is slightly soluble in water, and after it dissolves, air acting on the solution precipitates what is commonly called rust. To lessen corrosion iron must be made less soluble in water. Mr. Speller spoke on the effects of carbon, manganese, phosphorus, sulphur, silicon, oxides and cinder. Black cinder in iron accelerates corrosion by setting up galvanic action.

Uniformity in metal is the keynote to the whole situation. It must be uniform chemically as well as physically. At the works of the National Tube Co. physical uniformity is obtained by the use of specially knobbed rolls. To produce the best metal it is necessary to have central control over the various stages of manufacture and a system of checking the quality of the product on its way through.

Joseph H. McNeil, chief inspector and chairman of the Massachusetts Board of Boiler Rules, made a plea for more legible stamping of steel. Boiler inspectors find it difficult to identify steel after it has been rolled and made up into boilers. After an accident it is of the greatest importance to know the kind of steel and its maker, and this information cannot be readily ascertained unless a legible stamp has been imprinted on the sheet.

James G. Shaw conveyed the best wishes of the New York association and F. S. Allen, of Hartford, spoke briefly on the advancement of the engineer and the duties of the present-day inspector.

Frank Hinkley, an inspector of the Massachusetts District Police, referred to the three distinct bills now before the legislature of Massachusetts and urged the adoption of a separate and distinct department on boiler inspection.

John Molloy, retiring president, spoke on the benefit derived from the association both educationally and socially. He referred to the conditions of inspection twenty to thirty years ago when there were no laws, no regulations and nothing to guide the inspector except the orders of the company employing them. The inspectors are now a unit, they have a uniform set of instructions and Mr. Molloy is proud of the Massachusetts rules.

Other speakers of the evening were H. Cave, W. D. Haggerty, G. H. Lloyd, Henry M. Feldmann, T. G. Ranton, C. J. Nyquist and the new president, M. S. King.

Bad Breakdown at Manchester (Ia.) Power Plant

Early on Sunday morning, Apr. 14, while the large Corliss engine in the Manchester Light, Heat & Power plant was furnishing the power for the electrical machinery, the mammoth drive rod became unjointed in some unaccountable manner, and before the night man was able to shut off the steam the large cylinder head was forced out, causing a mishap which, had it happened during the day time, would have undoubtedly resulted seriously.

Boiler Inspectors at Annual Banquet in American House, Boston

The company has recently installed an additional engine and dynamo. The damage to the engine is considerable, and it will be some time before it can be repaired.

Explosion in Chicago Steel Plant

On Apr. 14, the daily press reports a gas explosion in the power house of the Illinois Steel Co.'s South Chicago plant. The building was wrecked and the lives of over 100 workmen were endangered. There was a property loss of over $100,000.

Boiler Explosion at Kelso, Washington

The boiler in a small sawmill near Kelso, Wash., blew up early on the morning of Apr. 23, writes a correspondent from the West, and three men were badly scalded. The property damage is estimated at $1000. No information as to the probable cause has yet been ascertained.

Three Killed at Fredericksburg, Va.

According to press reports, three men were killed and three severely injured by the explosion of a boiler in H. N. Newbil & Son's sawmill, near Fredericksburg, Va., on Apr. 19.

Fatal Locomotive Boiler Explosion near Winnemucca, Nevada

On Apr. 22, near Winnemucca, Nev., the engine on freight train No. 49 exploded, killing the engineer, fireman and head brakeman, as stated by the local press.

The engine was completely wrecked, five cars were derailed and the track torn up for a considerable distance. The cause is unknown. It is said that the engine had been thoroughly overhauled and repaired and inspected by the state officials.

Killed by Bursting Boiler

At Bloomington, Ind., on Apr. 26, engine No. 217, while in motion in the Monon yards, was badly wrecked by the explosion of its boiler. The engineeer was instantly killed, and the fireman, who probably owes his life to the fact that he had just filled the firebox and was sitting on the tender, was hurled across two tracks, over a caboose and landed on the next track. Although he was severely burned about the face and arms, no bones were broken, and he is likely to recover. The engineer was thrown through both sides of a box car nearby, a part of the cab going with him, and was picked up lifeless 50 ft. away.

The press reports are unable to say whether the accident was due to high pressure, low water or to faulty boiler construction.

Formerly used both in the Bloomington yards and on the road, the engine was rebuilt and used as a pusher up to the time it exploded. The state boiler inspector will make an investigation.

OBITUARY

Hinsdale Parsons

On Apr. 28, Hinsdale Parsons, vice-president and general counsel of the General Electric Co., was instantly killed by the overturning of his automobile, near Albany. Mr. Parsons was 45 years old, and had been associated with the General Electric Co. since 1894 as counsel, and in 1901 was elected vice-president.

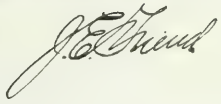
He is survived by his wife and four brothers. James, another brother, who was U. S. consul at Mexico, was killed in a similar accident five years ago.

Jacob E. Friend

Jacob E. Friend, of Milwaukee, Wis., president of the Nordberg Manufacturing Co., and a prominent resident of that city, died suddenly from heart disease in the street in Florence, Italy, on Apr. 20, while *en route* to New York from a trip through the Orient. Mr. Friend was accompanied by Mrs. Friend and their daughter Margaret, who sailed from Florence to New York on Apr. 25, and have, it is said, brought the remains with them.

Mr. Friend was born in Milwaukee 54 years ago, the only child of Mr. and Mrs. Elias Friend. He was educated in the local schools, and later took a course in the Columbia Law School, New York City. Soon afterward he engaged in law practice in his home city, and formed a partnership which continued until a few years ago, when he retired to take an active part in the affairs of the Nordberg Manufacturing Co.

Soon after attaining his majority, Mr. Friend served a term in the Wisconsin Legislature. He was a prominent member of several social clubs, a director in a bank and several insurance companies, and figured in many large commercial enterprises.



PERSONAL

Warren B. Flanders, who has been connected with the steam-turbine department of the Westinghouse Machine Co., East Pittsburg, Penn., left on May 1 to accept a position with the Havana Electric Co., of Havana, Cuba.

Clark, MacMullen & Riley, Inc., consulting engineers for the design of heating, ventilating and electrical equipments, have removed their offices to the Eighty Maiden Lane Building.

Correction: The curve in Fig. 2 of the article under the title "Calculation of Heat Value of Coal," in the issue of Apr. 16, pages 558 and 559, is copyrighted by the Under-Feed Stoker Co. of America. A statement of this fact was inadvertently omitted from the article.

Moments with the Ad. Editor

"Three illusions are common to nearly all men. Nearly every man thinks that he thoroughly understands human nature, that he can run the local newspaper better than the editor runs it, and that he can write advertising."

So delivers himself a prominent national advertiser—who is besides, we might add, a keen analyst of his fellow-kind, with some right notions on advertising in general.

"That he can write advertising!"

You all have heard and perhaps know some specimens of the fellow who thinks he could make Greeley, Dana, Pulitzer & Co. look like twenty-nine cents in the newspaper game (if he only wanted to)—and you know the other fellow, who believes he can read and interpret, without a miscue, all the motives, actions and secret thoughts of the folks next door.

But—the man who thinks he can write advertising if he only wanted to—he's a newer phenomenon. New, probably, because advertising in the right sense is itself more or less new.

Why is it so many people think they can write advertising, especially those who, able or expert in some other line, really haven't the least qualification or aptitude for the job?

Because advertising is thought of as authorship—as writing.

We're a nation of authors. Go past the newsstand for proof. Doctors, lawyers, merchants, thieves, professors and old ladies—write. If a financier or a second-story operator is laid up at home with the gout or laid out at home with a billy, he fills in the enforced leisure by writing a book—about something. Novel, poem, play, essay, book of travels, "true" story of somebody, "appreciation" or damnation, *something* about *something*. And everybody reads—reads—reads.

Thus, it is easy to account for such widespread belief—or conceit—in ability to write advertising, when advertising is looked on as "authorship."

But consider a moment—

These tons of cheap, hurriedly, ignorantly written novels, stories, plays, etc., that stack the newsstands—people are not really *influenced* by reading such. Such stuff is bought to fill in the time, exactly as a lot of it is written—because the writer didn't have anything else in particular to do.

Now, *advertising* that is *written* in this way, will be *read* in this way. It'll be a soporific (see Dictionary!), not stimulus to action.

But, let us whisper you this—

Real advertising is *only incidentally* writing. It is salesmanship that simply happens to be talking *per* the printed page—"happens to be," because it found a magnificently big opportunity to talk thus *through the eyes* of ten thousand humans at once instead of *through the ears* of the ten thousand in succession—if it could find 'em.

Of course, let us hasten to say, advertising has not shoved the real genus homo salesman out of his job, any more than the telephone has abolished letter writing; for, as the telephone simply does more swiftly and cheaply a myriad things the letter used to do, leaving the letter to confirm, to clinch the bargain, so with advertising and the salesman—who lands the prospect that the ad. fishes up, who closes the sale that the ad. begins, and who does some certain other things only a thinking man on two legs can do. One great advantage of advertising over the salesman system simon pure, outside of its superior economy, is that advertising *discovers possibilities of business* in places where the salesman never dreams of looking.

But we're talking just now about *writing* ads.—and the gist of it all, with which we end, is "these"—

AN AD., "as is one," can't be written by the fellow who hasn't in him the spark for firing others to action—feeling-action, thought-action—any more than the Odyssey could be written by the office boy. The real ad-man, ad-builder and ad-dreamer, instead of and far from being a mere pen-shover, is—75% of him at least—that vivid, imaginative, dynamic genius of this modern time—SALESMAN.

POWER

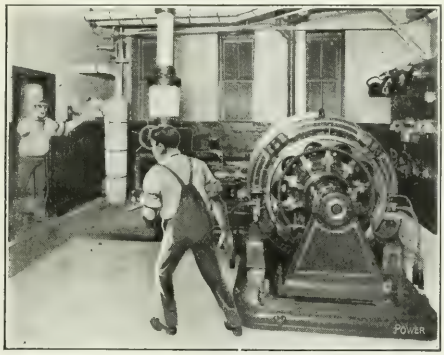
Vol. 35 NEW YORK, MAY 14, 1912 No. 20

THE tendency of most engineers upon taking charge of a steam plant is to show the "old man" what a valuable asset has been added to the establishment.

They feel compelled to disclose the shortcomings of their predecessors, and to point out where changes can be made which will work to the interest of their employers.

Now, ambition to make good is highly commendable, but it can lead an engineer into difficulties and saddle duties upon him which he should not perform.

The engineer has enough to claim his undivided attention in the steam plant without being obliged to go into the factory and care for shafting and belts, or do other mechanical work.



Once there was an engine runner—and he did his own firing—who was ambitious to make a showing, so he persuaded the management to hire a fireman so that he could put in more time in the factory and save the expense of a machinist.

This was done, and the engineer became a "jack-of-all-trades." A lathe was purchased at his suggestion, but he could not turn out good work; he failed to do his part because he was not a trained mechanic. Eventually the fireman was discharged, a machinist was engaged, and the engineer was sent back to the engine and boiler rooms.

It is all very well to try to cut down running expenses, but no man can do two or three men's work and make good.

There are ways of reducing expenses without going out of the engine or boiler rooms, and it does not require the wisdom of a Solomon to detect sources of loss.

It may be that the exhaust of a heating coil is blowing to the atmosphere; then trap it and pump the water back into the boiler.

It may be that the steam pipes are bare; then cover them and prevent excessive condensation and wet steam.

It is more than probable that the blowoff valve is leaking; it does not take much of a leak to waste a large amount of water under a pressure of 100 lb. or more.

Some boiler settings are cracked and air leaking into the furnaces produces poor combustion. It does not take long to stop up the cracks, and careful regulation of the damper and a better method of firing will materially reduce the amount of fuel consumed.

The safety valve may leak steam 24 hours a day; total loss, because no work has been done, although coal has been burned in evaporating the water into steam.

Larger wastes are easily discovered. They are self-evident, but the small sources of loss are usually passed unnoticed, or else are considered of no account.

The place for the engineer to make his showing is in the power plant, not out in the shop. An engineer should not attempt to be general machinist, repair man, or roustabout. If he keeps his engine and boiler in condition, he will have all the work to which he can properly attend.

Aeolian Company's New Power Plant

By Warren O. Rogers

A remodeled high-speed engine plant.

A feature is the method of handling the fuel and ash.

The coal bin is made in two parts, the lower holding a reserve supply of fuel.

A few years ago it was customary for manufacturing companies to pay scant attention to the design of the power plant, and woodworking industries were specially lax in their attention to the power end of the business. Of late years, however, the steam plant has received attention more in keeping with its importance.

The remodeled power plant of the Aeolian Co., at Garwood, N. J., is an example of an uptodate installation for woodworking establishments.

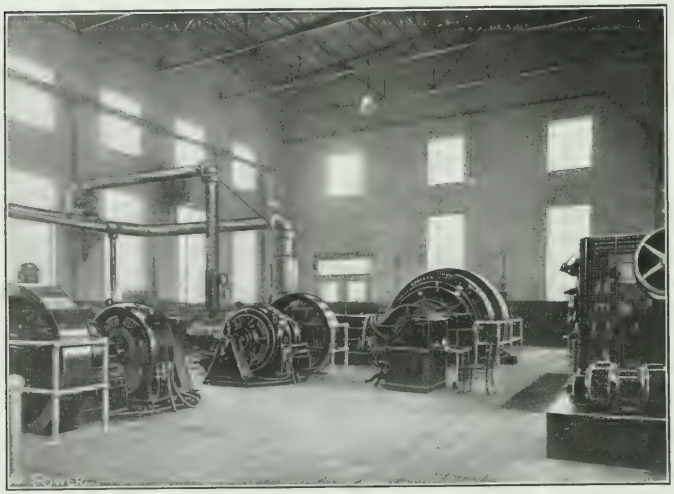


FIG. 1. THREE OF THE FOUR GENERATING UNITS

The power house is constructed of brick with a tar gravel roof. Both engine and boiler rooms are well lighted and a liberal amount of space has been allowed for the machinery throughout the plant.

ENGINE ROOM

A view of the engine room is shown in Fig. 1. There are three 14x14-in. high-speed engines and one cross-compound medium-speed engine having cylinders 20 and 34 by 28 in. These engines are all direct-coupled to 250-volt direct-current generators. The electrical energy is transmitted from the switchboard to the factory for motor and lighting service by means of a three-wire system. Two balancing sets are used to balance the load.

FEED-WATER APPARATUS

Water for the boilers is obtained from a 203-ft. driven well, and the Pohle air-lift system is used. An 8 and 10 by 8-in. air compressor supplies the compressed air for lifting the water which is discharged into a storage reservoir, while the water for factory use is pumped into a 10,000-gal. tank which is mounted on a tower. Either a motor-driven pump or a duplex pump handles the factory water supply, the latter being used when the plant is shut down.

There are two boiler-feed pumps, both of the outside-packed type. The water is heated to 210 deg. F. in passing through an open feed-water heater. There is also an underwriters' fire pump with a maximum capacity of 1000 gal. at 70 r.p.m. per minute. This pump is piped to a concrete reservoir located in the yard which has a water capacity of 148,000 gal.

BOILER ROOM

In the boiler room, shown in Fig. 2, there are three 400-hp. water-tube boilers which carry a steam pressure of 165 lb., the steam being superheated 100 deg. The furnaces are controlled by a balanced draft system. The necessary air is supplied to the furnaces by a fan, shown in Fig. 3, which is driven by one of two engines, one of which is uncoupled and held for emergency use. The speed of the fan engine is controlled by a damper regulator which is governed by the steam pressure. The smoke and gas of combustion pass from the boilers through a square steel flue to a brick chimney which is built in and at the end of the present boiler house. The stack foundation is constructed of concrete; Fig. 3 shows the base.

The position of the chimney provides for future extension of the boiler room,

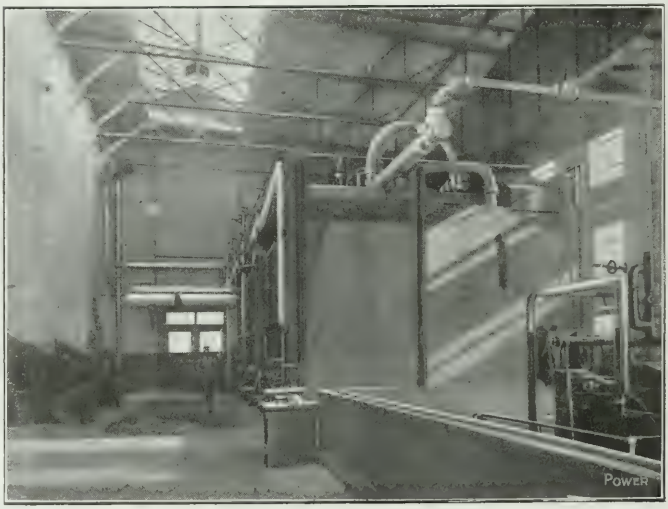


FIG. 2. THE BOILER ROOM, SHOWING FORCED-DRAFT UNIT AT THE RIGHT

in which case the chimney would receive the gases from the boilers from each side.

Coal Conveyors

Probably the most interesting feature of the plant is the method of handling the coal and ashes. A concrete coal bunker has been built on the outside of the boiler house, the inside wall forming the boiler-room wall, which is at the left in Fig. 2. The outside construction of the coal bunker and ash bin is shown in Fig. 4. Coal is delivered to the bucket coal conveyor from coal cars which discharge the fuel into the conveyor hopper that is located at the end of the coal bunker out in the yard.

The bucket conveyor runs in a metal casing on the outside of the bunker and discharges onto an endless belt conveyor, shown in Fig. 5. The belt conveyor runs at right angles to the bucket conveyor and the coal is discharged into openings which lead to the several pockets into which the bunker is divided. The openings and the discharge chute of the conveyor are shown in Fig. 6. Both conveyors are motor driven.

There are five sections to the coal bunker and each is provided with an overflow from the top to the bottom pockets, into which the bunker is divided by a concrete partition sloping from the back toward the front of the bunker, as shown in Fig. 7. When the top pocket has been filled to the level of the opening of the overflow, all additional coal drops through the overflow chute to the bottom of the bunker; and is held in reserve. In case the delivery of a cargo of coal is delayed, this reserve supply can be drawn upon and elevated to the top bunker by means of a belt conveyor which runs in a tunnel on the outside of the coal bunker. An opening in each pocket has been provided for this purpose.

In case it is desirable to empty the upper bunker, a gate has been provided in the slanting concrete partition. The top coal bunkers have a capacity of 730 tons, and the lower bunkers 540 tons. Coal is delivered from the top bunkers, through chutes to a metal coal car which runs on an industrial track. The plan view, Fig. 8, shows the layout.

Ash Conveyor

The ashes are handled by an ash suction conveyor. The bottoms of the ashpits are about 3 ft. above the basement floor, the dividing wall in the basement forming the front wall. Each ashpit is provided with a double clean-out door,

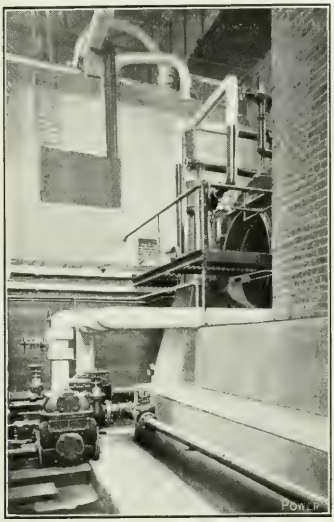


Fig. 3. A View of the Stack Pit

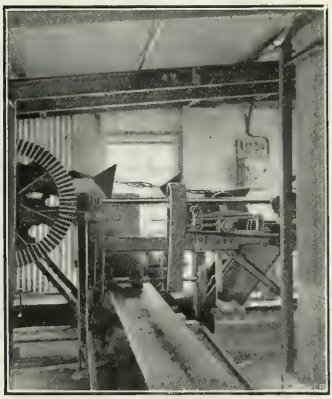


Fig. 5. Junction of Bucket and Belt Coal Conveyors

Fig. 4. Concrete Coal and Ash Bunkers, Showing Bucket Conveyor at the End

as shown in Fig. 9. In front of each clean-out door a concrete ash hopper, 4 ft. long, 3 ft. 9 in. wide and 3 ft. high, has been constructed. In the center of each is an 8-in. opening which connects to an 8-in. ash pipe that runs to the two ash bunkers located at the top and at the back of the coal bunker. Their position is shown in Fig. 7. The

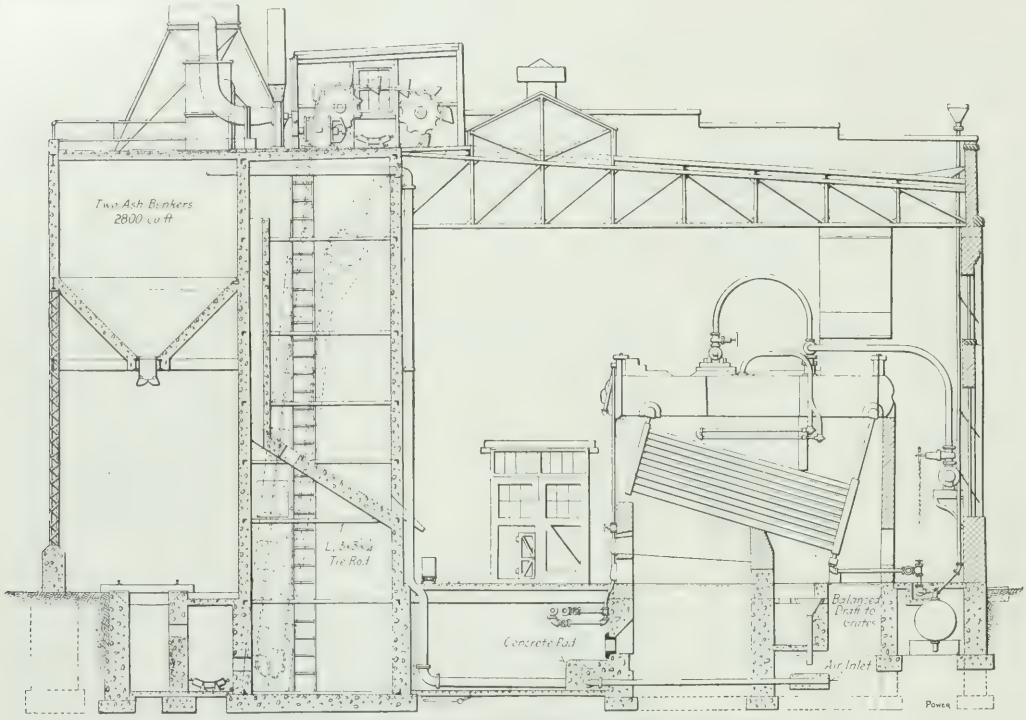


FIG. 7. END ELEVATION OF BOILER ROOM, COAL AND ASH BUNKERS

EQUIPMENT OF THE AEOLIAN POWER PLANT

No.	Equipment	Make	Use	Kw	Volts	Amp	R p m	Size	Pressure, Lb	Hp	Manufacturers
1	Engine	Ballwood	Main unit	400			150	20&34x28	165		Ball-Wood Co.
3	Engines	Ames	Main units	75			275	14x14	165		Ames Iron Works
2	Engines	Vertical	Driving fan					9x7	165		American Blower Co.
1	D.-c. generator	Crocker-Wheeler	Main unit	400	250	1600	150				Crocker-Wheeler Co.
3	D.-c. generators	Westinghouse	Main units	75	250		275				Westinghouse Electric & Mfg. Co
1	Volute pump	Watson-Stillman	Factory well				1525				Watson-Stillman Co.
1	Steam pump	Duplex	Factory supply					5½x4x5	165		Henry R. Worthington
1	Steam pump	Duplex, outside	Boiler feed					7½x5x6	165		Henry R. Worthington
1	Steam pump	Duplex outside	Boiler feed						165		Platt Iron Works
1	Duplex pump	Knowles	Fire					18x10x12	165		Blake & Knowles Steam Pump Works
2	Duplex pumps	Blake	Oil					No. 6			Blake & Knowles Steam Pump Works
1	Duplex pump	Knowles	Return system					8x10x12	165		Blake & Knowles Steam Pump Works
1	Steam pump	Duplex	Return system					8x12x12	165		
3	Steam boilers	Babcock & Wilcox	Steam generator						165	400	Babcock & Wilcox
3	Superheaters	Foster	Superheating steam								Power Specialty Co
1	Air lift	Pohle	Deep well								Ingersoll-Rand Co
1	Air compressor	Clayton	Well service					8x10x8	165		Clayton Air Compressor Works
1	Governor	Foster	Air compressor								Foster Engineering Co
1	Heater	Open	Feed water					No. 4			Platt Iron Works
1	Filter	Richardson	Oil								Peterson Engineering Co.
3	Balanced draft	McLean	Boiler furnace								The Engineer Co.
1	Fan	Sirocco	Forced draft								American Blower Co.
1	Fan		Ash system								Guarantee Construction Co.
1	Motor	Westinghouse	Driving volute pump	250	288					75	Watson-Stillman Co.
3	Motors	Direct current	Conveyors	220	39.5		700			10	Garwood Electric Co
1	Motor	Direct current	Ash fan							30	General Electric Co.
2	Balancers	Crocker Wheeler	3-wire system	125	30		1300				Crocker-Wheeler Co.
1	Controller	Sundh	Motor control								Sundh Electric Co.
3	Controllers	Cutler Hammer	Conveyor motors								Cutler-Hammer Mfg. Co.
1	Regulator	Mason	Fan engines						165		Mason Regulator Co.
1	Conveyor	Bucket	Coal								The Jeffrey Mfg. Co.
1	Conveyor	Belt	Coal								The Jeffrey Mfg. Co.
1	Conveyor	Darley	Ash								Guarantee Construction Co.
1	Chimney	Custodis	Furnace gases					178 ft high			Alfons Custodis Chimney Construction Co.
	Architects										Balch & Beardsley
	Consulting engineer										Otto G. Goldschmidt
	Chief engineer										J. A. Lane

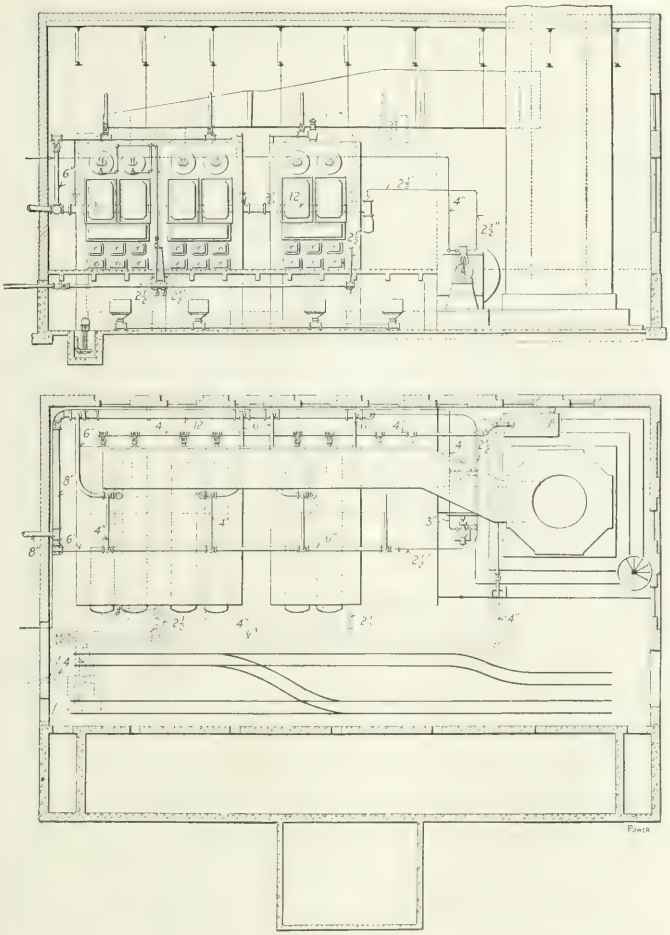


FIG. 8. PLAN AND SECTIONAL ELEVATION OF BOILER ROOM

ash bunkers have a capacity of 2800 cu.ft.

The sides of the concrete ash hopper slope toward the outlet opening, the top opening being 2 ft. 7½ in. wide by 2 ft. 9 in. long. At the side of the chimney, at the bottom, a clean-out door is provided so that the accumulation of fine ash can be hoed out into a 5-in. pipe which connects with the 8-in. suction pipe of the system.

In the roof monitor of the boiler room the fan and motor are located as shown in Fig. 7. The ashes are handled dry and are discharged into the ash bunker without coming in contact with the fan, which creates a suction in the ash pipe. The ash inlets are stoppered when not in use, but as soon as a cover is removed from an inlet opening a strong air blast draws the ashes and clinkers into the ash-storage tank.

Although the ashes are handled dry, they are wet upon entering the storage tank, where a water spray is used. The elbows of the ash pipe are made with detachable wearing plates at the turns. The ash bunker is supported by concrete piers and the ashes are dumped either into railway cars or into carts; one is shown in position for receiving a load in Fig. 4. The system of ash handling keeps the boiler room free from unnecessary dust and reduces the movable operating parts to the motor and fan.

FIG. 6. SHOWING BELT CONVEYOR AND DISCHARGE CHUTE

The University of Pittsburg is entering upon a study of the smoke problem, taking as its chief lines of investigation the effect of smoke on health, plant life and buildings. It is also considering the increased cost of living due to damage and dirt caused by smoke, and both the legal and the engineering side of the question.

FIG. 9. CONCRETE ASH HOPPERS OF ASH-CONVEYING SYSTEM

Raising Water by Compressed Air

By Frank Richards

Theoretical horsepower required to raise water.

One convenient, though inefficient, way of raising water is to use air in an ordinary direct-acting steam pump. The losses occurring in such a case are pointed out.

One of the most obvious uses of compressed air is that of raising and conveying water and other liquids, and this has also become one of its most extensive fields of employment. The variety of ways in which the air is applied for this purpose and the diversity of the apparatus that has been devised are astonishing. While many have nothing more than a historic interest; the actual practical ways in which air now is employed for pumping, while differing widely from each other in efficiency and other particulars, are not numerous, yet they would be none the worse for still further elimination. The conditions under which the water is to be raised largely determine the specific device employed in the individual case, but sometimes other considerations not so defensible prevail in the selection or in the retention of deservedly obsolescent systems.

There is, according to the system adopted, much difference in the amount of air consumed as compared with the work done, but in all cases the former must be in excess of the theoretical requirement, as nothing can be done for nothing. With our present knowledge, it still pays in many cases to use air for raising water, in both small and large quantities, and as a means of permanent supply as well as in temporary or emergent cases.

It is desirable not only to do but also to know that we are doing the work as cheaply as possible. Our present facilities make the metering of water lifted or transferred an easy thing to do, and the raising of water, by compressed air or otherwise, can always be gaged with satisfactory accuracy, while records of such work are constantly accumulating and are accessible as guides to the engineer.

The theoretical horsepower required for raising water is

$$\frac{\text{Pounds of water per min.} \times \text{height of lift in ft}}{33{,}000}$$

The accompanying table may be taken as a starter; it furnishes the essential data as to the power required for raising water to different heights. It gives also the actual potential energy in the water so elevated, or the power which it should be theoretically possible for the water to develop in its descent to normal level if employed in a water-wheel or motor. When the power actually consumed in a water-raising operation is ascertained it can be compared with this table and the result will be an indication of the efficiency in the given example.

The first column gives the number of gallons of water lifted; column 2 gives the volume in cubic feet of the given number of gallons, while column 3 gives the weight in pounds of the same quantity of water. Column 4, assuming that the given quantity of water—gallons, cubic feet or pounds—is raised to a height of 100 ft. in a minute, gives the horsepower theoretically required for the lift, or the horsepower which should be developed by the descent of the water to its original level. Any other figures or quantities not in the table will be in direct proportion to those given.

Driving Steam Pumps with Air

First of all (as an example of "how not to do it") consider what it costs to drive an ordinary, direct-acting steam pump by compressed air. It is often so convenient to do this, in mines, tunnels, excavations for foundations and elsewhere, that it is done generally without counting the cost, either before or after.

The simplest case is where the steam or air and the water cylinders are of the same diameter, and have the same stroke. Here if there were no allowances to be made for clearance losses, leakages, power required to overcome friction and inertia, and if it had cost nothing to compress and transmit the air, all these and other things being those which pure theory is so apt to belittle or ignore—the volume of air at the balancing pressure would just equal the volume of water delivered and the efficiency would be 100 per cent.

The standards of efficiency called the possible efficiencies are really the impossible efficiencies. It is well known that they can never be attained, and very far from it in the present case. The air pressure must be enough in excess of the water pressure to overcome the frictional resistance of the machine itself and of the water in contact with the surfaces in its restricted flow through valves and passages, and to give and maintain sufficient impulse in the otherwise inert column. For all this it will be proper to allow an initial deficiency in the air power at the pump which will average not less than 20 per cent., and the 100 per cent. efficiency with which the author started is reduced to 80 per cent.

But if there is such a deficiency, the pump will not go. This is understood; and the several deficiencies are anticipated and provided for beforehand by furnishing air in sufficient volume and at an excess of pressure to overcome them.

To run a pump comfortably the working pressure of the motor fluid should be somewhat above the actual requirement, but it is not necessary to speak of that here as affecting the power consumption.

Next, the matter of cylinder clearance may be considered, which is interesting in the direct-acting steam pump at any time, and especially so when the pump is driven by air. Nothing need be said about clearance losses in the water cylinder, for practically there are none, as all the spaces may usually be assumed to be filled solidly with water, and if everything is in good order all of the actual travel of the water piston is represented by water delivered.

Enough clearance losses in the air cylinder may be found to satisfy for both. The direct-acting pump has no crank to bring the piston to a dead stop always at the same point at the end of the stroke, and, as at the same time it must be certain that the piston shall never strike the head, very large clearance is provided. The filling of this large clearance together with that of the unavoidable clearance spaces in the passages between the valves and the cylinder, entails another large excess of air over that theoretically required, or a deficiency of work done as compared with the air consumed of, say, another 20 per cent. This percentage of 80 being 16, 64 per cent. of the original 100 at this point is left.

There is a third great loss of efficiency when compressed air is used to drive a direct-acting steam pump because the air is used at full pressure and shows none of the advantages of being used expansively. If, instead of using the air at its highest pressure to fill the cylinder to the very end of the pumping stroke, it could have been used in a crank-and-flywheel pump, or in one of any other design in which the air could have been cut off at the proper point of the stroke, so that it would have been discharged at a pressure nearly that of the atmosphere, then the work done for the quantity of air used would have been, on the average, varying with the initial pressure of the air, say, 50 per cent. more than without the cutoff and expansion. That is, it could and would have done one-half more work, and the failure to do this amounts to another deficiency of one-third, or, say, 33 per cent. This percentage of 64 being 21, there is left only 43 per cent. of the original 100, and this diminution of efficiency is all realized after the air has arrived at the pump and without look-

ing to the losses which have accumulated previous to its arrival on the job.

Not to Be Charged to the Air

Now, the curious thing is that not one of the losses here mentioned, nor any portion of any of them, is in any way chargeable to compressed air. They all inhere in the apparatus and in the system by which the air is applied to the work of lifting the water.

One loss peculiar to steam and entirely absent with air is the loss by condensation, concerning which it is not necessary to present any figures. It is plain that the air should not be blamed for any of the losses of which it becomes the agent when driving the steam pump.

Thus far, the direct-acting pump alone and its deficiencies or those which it entails, have been considered. Of course, the pump has nothing to do with the friction losses in transmission from the compressor to the pump. For all such losses and for all possible leakages allowance in the air-compressing cylinder would be only 22 per cent. instead of 34, and the loss in the pump air cylinder through not using the air expansively, would be relatively the same so that there would be a saving at both ends.

[A second article will appear in an early issue in which two types of air-lift system will be described.—Editors.]

TABLE OF STATIC WATER POTENTIALS

1	2	3	4	1	2	3	4
Gal.	Volume, Cu.Ft.	Weight, Lb.	Potential Hp. in Water Raised 100 Ft.	Gal.	Volume, Cu.Ft.	Weight, Lb.	Potential Hp. in Water Raised 100 Ft.
1	0.13368	8.355	0.025303	200	26.736	1671	5.0606
2	0.26736	16.710	0.050606	250	33.420	2089	6.3257
3	0.40104	25.065	0.075909	300	40.104	2506	7.5909
4	0.53472	33.420	0.101212	350	46.788	2924	8.8560
5	0.66840	41.775	0.126515	400	53.472	3342	10.1212
6	0.80208	50.130	0.151818	450	60.156	3760	11.3863
7	0.93576	58.485	0.177121	500	66.840	4177	12.6515
7.48	1	62.5	0.18928	550	73.524	4595	13.9166
8	1.06944	66.840	0.202424	600	80.208	5013	15.1818
9	1.20312	75.195	0.227727	650	86.892	5431	16.4469
10	1.3368	83.55	0.25303	700	93.576	5848	17.7121
20	2.6736	167.10	0.50606	750	100.260	6266	18.9772
25	3.342	208.87	0.63257	800	106.944	6684	20.2424
50	6.684	417.75	1.26515	850	113.628	7102	21.5075
75	10.026	626.62	1.89771	900	120.312	7519	22.7727
100	13.368	835.50	2.5303	950	126.996	7937	24.0378
150	20.052	1253	3.7954	1000	133.680	8355	25.303

low, say, 5 per cent., deducting which from the 43 per cent., found above, leaves 41 per cent., all the rest having disappeared after the air left the compressor. The transmission loss just allowed would be greater with steam, while some of the distances which air may be carried are prohibitive with steam.

While the cost of compressing the air used is not considered, attention might be called to the approximate figures for compressing free air to, say, 80 lb., gage. Assuming a steam-driven, reciprocating air compressor and both compressor and pump to run regularly under their respective rated loads, the power which is being developed in the steam cylinder may be taken as a starting point or the basis of efficiencies. First must be deducted a sufficient allowance for the friction of the entire machine and for the leakage and clearance and other air-cylinder losses, amounting altogether to an inefficiency of at least 20 per cent., leaving 80 per cent. Then in the compression of the air the excess of power required for the actual adiabatic compression, instead of the theoretical isothermal compression, will be 34 per cent. This percentage of 80 being 27, the surviving efficiency will be 53 per cent. This being the efficiency of the compressor and 41 per cent. the pump efficiency, the ultimate efficiency of the combination is 21.73 per cent.; that is, it will take about 5 hp. in the steam cylinder of the compressor to realize 1 hp. in the actual lifting and delivery of the water. Actual results are seldom any better, and often much worse, than this in practice.

At least one hint may be taken from these figures, which is that the loss is the least where the working air pressure is the lowest. In the case of the direct-acting pump the difference may be made in the relative capacities of the air (driving) and the water (driven) cylinders, and, in general, the larger the former is, the better. Thus, supposing the air to be used at 40 lb., gage, instead of 80, the excess of mean effective resist-

Idaho Power Co. to Develop Large Irrigation Tract

The Crane Falls Power & Irrigation Co., of Boise, Idaho, will soon install three large Westinghouse electric motors, aggregating 5645 hp., nine control switchboards and six 300-kw. self-cooled transformers to help irrigate the Gem irrigation tract, lying near the Snake River.

It is not believed that the company's pumping station, which is located on the Snake River, will be completed and ready to commence pumping until 1913.

Red Lead Joints

By A. L. Haas

The many jointing materials now advertised as being the best for the purpose have obscured the old reliable red-lead putty.

To make a first-class joint, the white lead used must be unadulterated. Only the properly corroded product of metallic lead bought under a written guarantee should be used. To test for its purity, place a weighed sample in a plumber's ladle and heat; the linseed oil (if putty) will then be driven off and the heating being continued, 85 per cent. of the original quantity should reduce into blue metallic lead. Barytes, a chalky substance, refuses to reduce and can be detected by color, appearance and weight from the quantity of lead oxide present in the ladle. If a sample known to be impure is reduced in a ladle against a sample of genuine white lead, the experience gained will safeguard the user against possible future fraud.

It is impossible to stock red lead ground in oil, which is putty, for the reason that it sets in bulk as hard as stone in less than a week; when wanted for paint purposes it is ground as required. This fact explains its peculiar suitability as a jointing material.

The genuine white lead and boiled linseed oil having been obtained, proceed to work up as much dry red lead as possible into the white-lead putty, moistening it with boiled oil while mixing. Its condition at the finish should be quite plastic and soft under the fingers.

Red lead should not be used for joints certain to be repeatedly broken; sheet packing is the best. Three or four days should be allowed for a red-lead joint to harden before admitting steam. As taking up on the nuts cannot be done with this type of joint, it must therefore be ruled out for hurry-up jobs.

Means must be provided to prevent the plastic putty being squeezed out between the flanges; stranded lamp cotton, spun yarn, etc., have all been used for this purpose, not to forget corrugated copper and brass gaskets and, what is probably the best of all, wire gauze.

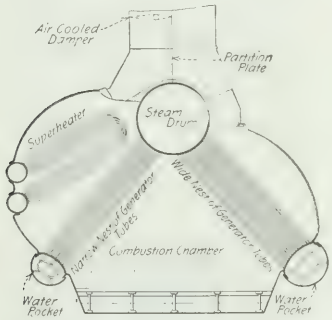
Where the face of the flange is pitted or rough, a wire-gauze joint interlaced with a couple of turns of lead wire and filled with red-lead putty, the completed joint being given time to harden, is a good remedy for a joint which proves repeatedly troublesome.

When it is clearly understood that a properly made red-lead joint lasts for the same length of time as the metal flanges, it proves that its choice has rested upon solid merit. Joints broken after 30 years of service without a leak show, when the castings have gone to the scrap heap, that the flange faces were like new metal and were as bright as the day they were machined.

A widely recommended joint cement having a secret formula proved to be litharge and adulterated white lead mixed, and contained a proportion of iron filings. It was used as a substitute to red lead when mixed with boiled oil. Its composition led to the belief that litharge might be profitably used as a good joint cement. Its ability to assist poor and adulterated paint to dry quickly points to its use where red lead might be inadmissible on account of the time required to harden it.

New Arrangement of Superheater with Yarrow Boiler

In a paper read before the Institution of Naval Architects on Mar. 28, Harold E. Yarrow, of the well known firm of Yarrow & Co., Ltd., described a special arrangement of superheater in connection with a Yarrow water-tube boiler.



SUPERHEATER APPLIED TO ONE SIDE OF YARROW BOILER

Formerly, the application of superheated steam to marine practice met with two objections: Owing to the dryness of the steam, oil for internal lubrication is reciprocating engines becomes a necessity and this oil, finding its way into the boilers, causes trouble. Again, there is danger of burning the superheater when the demand for steam is suddenly reduced.

The first of these objections has been overcome by the introduction of turbines into marine work and the arrangement described by Mr. Yarrow is intended to meet the second objection. Referring to the illustration which represents a cross-section through the boiler, the superheater is shown placed over the left-hand nest of tubes. It will be observed that there are fewer rows of tubes on this side of the boiler, this being done so that the total heating surface and the resistance to the gases on both sides of the boiler would be practically the same. The total heating surface of the boiler was 6700 sq.ft., of which 1265 sq.ft. was superheating surface.

The superheater consisted of a number of U-tubes expanded into two longitudinal collectors, small doors being fitted so that access could be had to the tubes when necessary. A damper is placed in the uptake on the same side as the superheater and when this damper is closed, all the gases pass to the opposite side of the boiler. Thus if the main engines should be slowed down suddenly or stopped, or when raising steam, the superheater may be shut off by closing the damper and no damage will result to the tubes.

A further advantage of this arrangement is that when the demand for steam is suddenly reduced, not only does it prevent the tubes from overheating, but it also diminishes the output of the boiler at a time when a reduced supply is wanted, because only about one-half the heating surface comes in contact with the gases. To avoid the possibility of the damper becoming distorted through overheating, it is provided with a hollow spindle into which air is admitted, passing thence between the two plates of the damper.

In the evaporative tests referred to by Mr. Yarrow, oil fuel was used, one set of trials being made with the damper open and the other with the damper closed. The results of these are given in Tables 1 and 2 respectively.

Referring to Table 2, it will be seen that at the highest rates of evaporation nearly 2 lb. of oil were burned per square foot of heating surface per hour, disregarding the heating surface of the superheater side of the boiler. Thus the opposite side was subjected to the heating effect of all the gases plus half the radiated heat.

TABLE II. TRIALS WITH DAMPER SHUT

On these trials the heating surface was taken as the heating surface of the large nest of generator tubes = 3247 sq.ft.

Steam pressure, lb. per sq.in.	Air pressure, inches of water	Lb. of water evaporated per hour	Lb. of oil fuel per hour	From and at 212° Fahr. Lb. of water evaporated per lb. of oil per hour	From and at 212° Fahr. Lb. of water evaporated per sq. ft. of heating surface per hour	Lb. of oil fuel per sq. ft. of heating surface per hour	Temperature of feed water, deg. Fahr.	Temperature of uptakes, deg. Fahr. above large nest of generator tubes
242.0	4.85	68,648	6287	13.25	25.66	1.936	61.0	913
242.25	3.97	57,693	5065	13.84	21.6	1.56	60.0	843
242.4	2.491	44,050	3504	15.3	16.5	1.09	60.3	673
242.5	1.46	31,481	2473	15.4	11.75	0.76	63.5	603

TABLE I. TRIALS WITH DAMPER OPEN

On these trials the heating surface was taken as the total heating surface of 6700 sq.ft.

Steam pressure, lb. per sq.in.	Superheat in deg. Fahr.	Air pressure, inches of water	Lb. of water evaporated per hour	Lb. of oil fuel per hour	From and at 212° Fahr. Lb. of water evaporated per lb. of oil per hour	From and at 212° Fahr. Lb. of water evaporated per sq.ft. of heating surface per hour	Lb. of oil fuel per square foot of heating surface per hour	Temperature of feed water, deg. Fahr.	Temperature between small nest of generator tubes and superheater, deg. Fahr.	Temperature in uptake, deg. Fahr. Above superheater	Temperature in uptake, deg. Fahr. Above large nest of generator tubes
242.0	93.5	5.0	94,659	8286	14.6	18.0	1.237	58.0	1121	828	887
243.0	93.0	3.16	76,021	6454	15.0	14.4	0.9635	63.5	926	698	727
243.7	82.5	2.44	68,387	5695	15.2	12.9	0.850	63.5	903	685	688
242.8	61.1	1.7	46,041	3650	15.9	8.6	0.542	64.0	647	536	551
241.8	31.0	0.998	20,059	1540	16.1	3.7	0.230	62.2	481	432	448
242.2	20.75	0.625	8,478	649	16.1	1.55	0.096	63.5	465	409	416

Life Saving at Sea

The American Museum of Safety has announced that Judge Elbert H. Gary, on behalf of the United States Steel Corporation, has presented the museum with $5000 toward obtaining a collection of the best devices for saving life at sea, as a permanent exhibit for demonstration, free to the public.

Early next month, Director W. H. Tolman will attend the International Congress of Accident Prevention at Milan, and study the best European methods for life saving at sea, and the prevention of injurious effects of occupational diseases.

Arthur Williams succeeds Philip T. Dodge in the presidency. Mr. Dodge has withdrawn on account of ill health. President Williams announces another gift of $5000 from an "unknown friend" for research work in connection with industrial poisons.

The public is invited to visit the museum, at 29 West Thirty-ninth St., any day between 9 a.m. and 5 p.m., and inventors and others with practical ideas for life saving at sea are invited to submit them at the museum.

Home Made Hoists

By K. P. Everette

Realizing that the erecting work is often a large proportion of the total cost of small engines, a newly incorporated electric-light company thought it good policy to employ a chief engineer who would be as capable of installing the machinery as of operating it. Such a man was engaged and he immediately made all necessary preparations while the foundations were being built. The absence of overhead girders and the scarcity of blocking timber showed the necessity of some form of crane, so he constructed the acute-angled gallows frame shown in Fig. 1. The advantages of this form are obvious at first sight; it is self-contained, and is so supported and braced that it may be moved about while carrying its load centrally without danger of tipping over or spreading the legs. When such parts as connecting-rods are to be hoisted an overhang two-

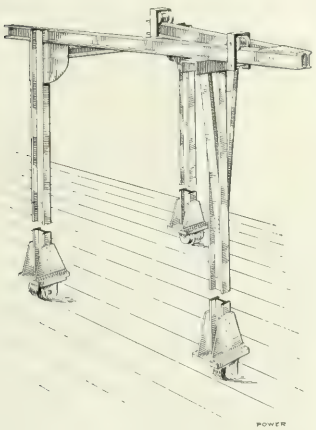


Fig. 1. Acute Angle Gallows Frame

bearing lift is obtained, and variations in the height of either end are easily secured by hoisting more on one block than on the other. When only one of the two travelers is needed, it can be placed at any convenient point; there are few spots around an engine or its auxiliaries over which some portion of the frame cannot be pushed. To move a heavy weight borne forward by both travelers away from the vertex of the angle, slings and spreaders are needed to cause the weight to descend slightly instead of rising. Its chief disadvantage is that when hoisting at any point beyond the center of gravity of the frame the opposite end must be weighted down to balance the load. The illustration amply shows the method of construction.

In a certain power station the condenser tubes require frequent renewal of packing; therefore the heads have to be removed. To facilitate this a 12-ft. piece of rail was secured on top as a track for a traveling head as shown in Fig. 2. The cover can be turned around, allowing the replacing of tubes, and by turning the bolt *A* it can be hoisted a

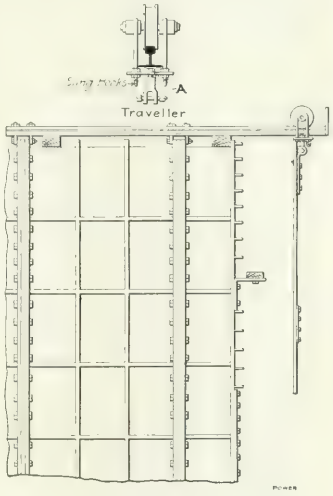


Fig. 2. Traveler and Track

trifle to clear the studs. A cheap and quickly made temporary derrick is shown in Fig. 3. Its capacity depends on the size and quality of the timber used, and the method of weighing down or otherwise securing the heel. A modification of this bearing a small flywheel is shown

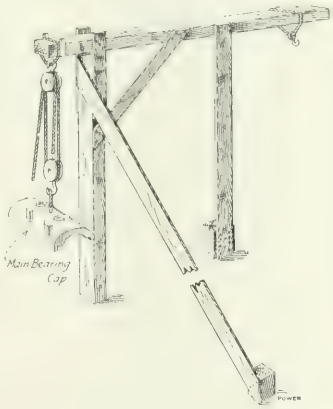


Fig. 3. Improvised Derrick

in Fig. 4. If the ceiling cannot be used to brace against, the beams may be secured by rope to the floor below, though this method would require more bracing lumber not heavier than 2-in. stuff.

The center of the wheel can be tilted either way to bring it square with the shaft. This is also a good form of rigging for placing the crankshaft of a center-crank engine in position to babbitt

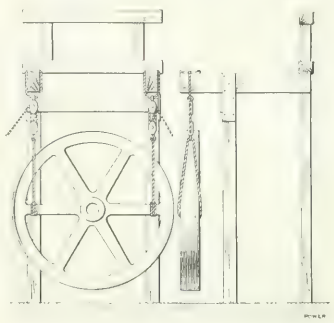


Fig. 4. Modification of Fig. 3

its main bearings. In one boiler room the furnace ashes had to be carried out through the engine room, a most inconvenient and dusty arrangement. To overcome this the engineer cut a large opening in the partition between the boiler

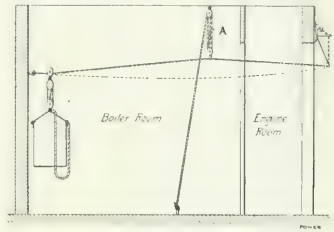


Fig. 5. Ash Conveyor

and engine rooms and then slung a slack 1¼-in. rope between the two opposite walls. A little beyond the middle of the rope a pair of small tackle blocks were secured as shown in Fig. 5. The manner of operation is apparent if it is supposed that the ash can is about to start on its journey, which is done by lowering on the central tackle *A*. When the block is reached it takes only a moment to change the hook to the other side of the load and hoist again, thus causing the ash can to continue its slide right out through the opened door.

Draft in the Boiler

By Everard Brown

The use of the word draft when applied to steam boilers is often misleading in that it may be applied to the motion of the gases through the boiler or it may mean the difference in the pressure producing this motion. Assuming the latter definition as correct, the greater the pressure difference the higher will be the velocity of flow because the motion is produced by an excess of pres-

sure at any given point over that at any other point toward which the flow is directed. This difference of pressure may be produced by chimneys, by exhausting fans or jets between the boilers and chimney and by pressure fans supplying air under the grate.

Of these methods the use of chimneys is the most prevalent and is commonly called the natural-draft system. Its popularity is due mostly to the fact that there is practically no expense connected with its operation. The performance of a chimney, however, is affected both by weather conditions and by the temperature of the escaping gases. This is due to the principle of its operation, which is simply to reduce the pressure within its base so that the greater atmospheric pressure without pushes air through the fuel bed and the gases of combustion through the boilers into the stack. The whole operation rests upon the expansion of the gases by heat, in consequence of which the weight of the gases in the chimney is less than if they were cold. It follows that the hotter the gases or the higher the chimney, the greater will be the difference in pressure.

The second method, that of installing an exhaust fan between the boiler and the chimney, is called the induced system, probably because the idea prevails that it draws the gases through the fuel bed and boiler. In reality, however, the fan simply forces the gases out of the casing and thereby reduces the pressure in it below that in the boiler, so that this excess pressure pushes other gas through into the space of reduced pressure, and so on. The use of an exhaust fan eliminates any necessity for a stack except as a means of carrying off the objectionable gases and its height may be governed accordingly.

The system is objected to by some operators on the ground that it causes excess air to rush into the furnace above the fire through leaks that might be in the setting or through the furnace doors. Such leaks in the setting, however, are always more or less injurious to economy and should not exist. The introduction of the induced draft in addition to that of the chimney may be made, for example, in old plants where an increase in the load or a different kind of fuel requires more draft than is available with the stack.

The third method, commonly called the forced-draft system, is to force air into the space under the grate and through the fuel bed, thus increasing the pressure therein above that of the surrounding atmosphere. With this system, as with the previous one, a high stack is not necessary except to carry the gases sufficiently high to be unobjectionable. Occasionally this and the induced-draft system are used together, as, for instance, with economizers. Forced draft, perhaps, has the advantage in that the amount of air going into the furnace can be regulated to suit the rate of combustion irrespective of weather conditions or gas temperatures, which is not the case with chimneys, and for this reason very little smoke is emitted from stacks where it is in use. It is always used with underfeed stokers.

The stronger the current of air through the fuel bed the higher, naturally, is the rate of combustion; also, the absorption of heat by the boiler increases with the strength of the current of gases passing over the heating surfaces. It is possible, therefore, to increase the working rate of the boiler in this way, although there are certain limits beyond which one cannot go because any advantages derived will be equaled or exceeded by the increased cost of operation. It would seem quite probable, however, that in some instances, the capacity of a plant could be doubled without necessitating any radical changes in the furnace or boiler.

Capacity does not depend altogether upon a great pressure drop through the fuel bed, but upon the difference between the pressures in the uptake and over the fire. Therefore, with a constant total draft, the boiler capacity varies inversely as the pressure drop through the fuel bed. In fact, a large drop through the bed usually indicates a high resistance to the flow of air and, consequently, a low rate of combustion.

Steam Consumption Per Horsepower Hour

By F. B. W. Barker

While most engineers are familiar with the use of the indicator and can use it intelligently in setting the valves and as an aid in obtaining the best economical operation of an engine, surprisingly few are familiar with the method of determining accurately the steam consumption of an engine or turbine per indicated or brake horsepower-hour.

For accurate engine tests surface condensers are employed, because the steam used by the engine is condensed and can be weighed or measured and the steam consumption determined directly. If the engine is operating with a vacuum, the condensed steam is removed from the condenser by the air pump, and when the engine is to be tested with the pressure in the condenser at atmosphere, the condensed steam can be removed by gravity.

The condensed steam is usually weighed in suitable tanks placed on accurate platform scales, but when very large quantities are to be measured the orifice method is the better. In this case the area of the orifice and the average head of the water must be accurately known and the discharge through the orifice calibrated under operating conditions.

As it is important that the condenser should be tight, it should be tested both before and after the test is made. If the engine is operating with a vacuum the same vacuum should be maintained in the condenser when it is tested for leaks. To test the condenser pass the condensing water through the tubes at its normal rate of flow, and note the amount of water, if any, collected in the steam space during a given time.

Another method would be to close all the openings to the steam area of the condenser and ascertain whether a vacuum can be maintained for a reasonable length of time. If salt water is used as a condensing medium, a solution of nitrate of silver can be added to a sample of the condensed steam and if no considerable cloudy precipitate of silver chloride appears, the condenser can be considered tight.

When a plant is operating noncondensing, or when condensing, and using a condenser in which the steam and condensing water mingle and the cost of installing a surface condenser would not be feasible, the steam used by the engine or turbine can be determined by the weight of the feed water entering the boilers, if they supply nothing but the engine under test.

This condition rarely exists, but in most plants having several boilers the steam piping can be so arranged as to disconnect one or more boilers from the battery, and supply only the engine.

Care must be taken that all the water entering the boiler is converted into steam and passes through the engine. All leakage in the boilers and piping should be stopped and the principal source of loss, the boiler blowoff connections, should be blanked. The quality of the steam should be determined at regular intervals, and the engine under test credited with the moisture which it contains. Still another method of obtaining the steam consumption of an engine having a barometric or similar condenser, in which the steam mingles with the condensing water and is discharged with it from the apparatus, is by the measurement of the amount of heat transferred from the steam to the condensing water.

The objection to this method is its unreliability, owing to the difficulty in obtaining the correct average temperature of a large volume of water flowing through a pipe.

The load on the engine should always be kept uniform throughout the test. It can be determined at regular intervals, with the indicator or prony brake, depending upon whether the steam consumption per indicated or brake horsepower-hour is desired.

By approaching his men in the right way, even the chief engineer occasionally picks up a valuable operating hint or improvement.

Kinetic Theory of Gases and Steam

By W. H. Booth

The pressure exerted by a gas inclosed in a vessel is considered as due to a continual bombardment of the walls of the the vessel by the molecules of the gas.

The action of steam in a condenser and in an engine cylinder is explained.

According to the kinetic theory, a gas consists of a great number of infinitely small molecules, each of which is endowed by its heat contents with mobility. Small as they are, these molecules have a certain mass, and the number of them in a cubic inch of steam has been calculated, as has also their mean free path or the distance they can travel without bumping against one another.

If a pump is set to draw out the contents of a closed vessel containing a gas, the time may be imagined when only one molecule remains. If this were visible, it could be seen to be darting about at a high velocity striking every wall of the vessel. By the kinetic theory the pressure of a gas is due simply to the impact of the gaseous molecules. It is said that a gas presses equally on every portion of its containing envelope. Substantially this is true, but it is not absolutely true, for the very nearly perfect vacuum of one molecule in a vessel, say of cubic shape and therefore possessed of six sides, cannot represent equality, all the pressure effect is concentrated on one of the six walls, and five walls are absolutely free of pressure.

No vacuum has yet been pumped so perfect as not to contain millions of molecules per cubic inch, and with such a number there is always practically an equality of pressure on every bounding wall, but one cannot be assured that the pressure actually and absolutely is equal on all sides.

As with all moving bodies, the gaseous molecules move in straight lines until deflected by collisions and by gravity. Gravity gives an additional velocity to the downward moving molecule and retards those which are moving upward; this accounts for the fact that gas pressure is greater at the bottom of a vessel than at the top. Thus in an air reservoir 10 ft. high, the pressure is higher at the base by about 0.005 lb. per square inch representing the increased impact due to a fall of 10 ft.

In a vessel containing a gas not all the molecules hit the sides, those next to the wall rebound and at once strike other molecules and bound back to the wall repeatedly. But the effect is the same, and the final result is that if there are two or more different gases in one vessel they will diffuse and form a mixture.

If a molecule hits a moving body it adds to the velocity of that body and bounds back itself at a speed less than it possessed previously. Thus the steam molecules in a cylinder may be imagined as bounding to and fro between the cylinder end and the piston face. They strike these two faces many hundred times per second for each molecule, and at each rebound from the moving piston they lose velocity; and since their temperature is due entirely to their velocity they are rendered colder. Thus it is evident why expanding steam in a cylinder is cooled and also why steam expanded into a fixed space is not cooled but superheated, for, the walls, not moving away from the molecules, cause the latter to rebound with their striking velocity and, therefore, do not lose heat, but if the walls are cold they absorb heat and the steam is thus made to move more slowly.

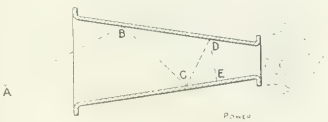


FIG. 1. CONVERGENT NOZZLE, WITH NO DEFINITE PATH FOR EXIT GASES

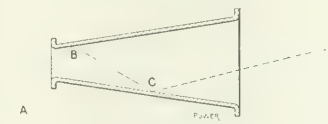


FIG. 2. DIVERGENT NOZZLE FROM WHICH GAS ISSUES IN A STRAIGHT PATH

There are many things one can learn from this kinetic theory. It is known that water-hammer is due to steam driving plugs of water along pipes toward portions of the pipes. Also, a body acted upon by an external force will increase in velocity to an infinite extent. This will apply to such a force as gravity which adds velocity at the rate of 32.16 ft. per sec. every second.

Now, this reasoning cannot be applied to steam and water-hammer. A plug of water 1 in. in cross-section and 30 lb. in weight will gain in velocity 32.16 ft. per sec. for each second it is urged by steam of 30 lb. pressure. But this is only true just at the start, for each second the force acts, the water moves more nearly at a velocity equal to that of the steam. When the water is moving at the molecular velocity of the steam it cannot move faster, for it would leave the steam behind. Hence, the velocity of water-hammer is thus limited to the molecular velocity of the driving steam.

Many marvel at the very slight movement of the vacuum gage when a large cylinder suddenly exhausts into a cold condenser. The pointer swings through a very small arc and promptly returns again, indicating that all the steam molecules found a cold surface. Since their velocity may be as high as 1800 ft. per sec., no molecule in a condenser of 18 cu.ft. could require more than 0.01 sec. before it reached a cold surface. The average time would be more nearly 0.005 sec. A poor vacuum in a condenser is due to the noncondensible gases being carried with the rush of steam upon the cold surfaces, which they blanket off from subsequent steam. Or if the cold surfaces get so much heat from the molecules of steam that they become heated, the steam molecules continue to bound back from them and produce back pressure.

One of the errors in condensing practice has been to place directly across the path of the steam a small fraction of the cold surface so as to form an almost continued wall of the first two rows of tubes. Now, however, it is more usual to leave gaps in the nests of tubes so as to insure a free path to the cold surface behind the first row of tubes, and so on.

One is apt to consider that all fluids are subject to the same influences with similar results, but there are distinct differences between elastic and inelastic fluids. Take, for example, the production of a smooth, easily flowing parallel jet of water issuing from a vessel, through a wide orifice contracted by easy curvature to a parallel end. The jet of a Pelton wheel is an example in point. But if a gas is made to issue through such an orifice it will spread out at the narrow end of the nozzle.

This effect is well shown in many liquid fuel burners which give a wide-spreading flame. The reason for the different behavior of water and of gas is that the water molecules are very much less active and are simply propelled by pressure from behind; the gas molecules are all free and very active. When they strike a surface they rebound at the angle of impact. Thus in Fig. 1 a molecule *A* follows the dotted line and makes equal angles at *B*, equal angles at *C* and equal angles at *D*. It arrives at *E*

and then strikes at an angle of 90 deg. and rebounds along its line of arrival, and if it were a lonely molecule it would simply retrace its path to *A*. This tendency explains the choking effect of such a convergent nozzle and the spreading out at the mouth of such molecules as get to that point with a movement transverse to the axis of the nozzle.

Now consider a diverging nozzle, as in Fig. 2, and start a molecule at *A;* it will strike *B* and *C*, making equal angles, and it is obvious that if the nozzle were only longer the rebound from the next impact *D* would be parallel with the axis of the nozzle. This tendency to parallelism belongs to every molecule and the jet no longer spreads out. Such jets are used in the De Laval and similar steam turbines and produce a maximum effect, for no molecules waste their energy by traverse movement or lateral expansion.

Of late, certain men have denied the existence of cylinder condensation as taught by Hirn. A small amount of condensation is admitted, but the greater part of the loss is attributed to valve leakage. Those who believe in Hirn's teaching cannot discover any proof of the more recent theory in any of the test figures put forward. The latter theorists practically deny the "kinetic theory" of gases for they speak of the impossibility of condensation occurring in so brief a space of time as in the stroke of a fast running engine. But an engine running at 600 strokes per minute occupies one-tenth of a second per stroke and every molecule of steam in the cylinder could travel about 200 ft. in the time of one stroke or, say, 30 or 40 ft. during the admission period. Such a velocity is ample for all the molecules to reach the cold walls.

The kinetic theory in thermodynamics is like the atomic theory in chemistry—a useful aid to the understanding of phenomena. Some people now deny the atomic theory, but it has long sufficed to carry chemistry along the right road. Indeed, in regard to the moving of a piston and to the effect on the steam thus produced by doing work, the kinetic theory affords a clearer insight to the whole mechanical and physical action than any other explanation or theory.

Bureau of Mines' New Publications

The following publications can be had on application to the director of the Bureau of Mines, Washington, D. C., if ordered by number and title:

Bulletin 10, "Use of Permissible Explosives," Clarence Hall and J. J. Rutledge; 34 pp. No. 23, "Steaming Tests of Coals and Related Investigations, Sept. 1, 1904, to Dec. 31, 1908," L. P. Breckinridge, Henry Kreisinger and W. T. Ray; 380 pp.

Technical Paper No. 8, "Methods of Analyzing Coal and Coke," F. M. Stanton and A. C. Fieldner; 21 pp. No. 10, "Liquefied Products from Natural Gas; Their Properties and Uses," I. C. Allen and G. A. Burrell; 23 pp. No. 11, "The Use of Birds and Mice for Detecting Carbon Monoxide After Mine Explosions and Fires," G. A. Burrell; 14 pp.

Reprint—Bulletin 34, "Tests of Run-of Mine and Briquetted Coal in a Locomotive Boiler," W. T. Ray and Henry Kreisinger; 32 pp.

Loss by Throttling a Turbine

A correspondent asks: "What is the loss in efficiency due to a drop of 10 pounds at full load across the throttle of a 4000-kilowatt turbine, the pressure at the throttle being 150 pounds, the superheat 100 degrees and the vacuum 28 inches?" The steam consumption under the above conditions is 16.6 pounds per kilowatt-hour. He would also like to know the gain in capacity due to eliminating this drop, if that were possible.

The energy generated by the drop of 10 pounds goes at first into accelerating the velocity of the steam through the constricted opening of the throttle. If the velocity in the pipe or chamber on the turbine side of the throttle is the same as that in the pipe upon the boiler side—that is, if the velocity after throttling is the same as before—the energy represented by the higher velocity in the throttling passage will be reconverted to heat when that velocity is destroyed and the throttled steam will have just as many heat units per pound as it had before it was throttled, but a smaller number of them will be convertible into mechanical energy because the initial "head" has been reduced.

The rule for finding the energy generated by expanding steam from one pressure and quality to another is

*From the total entropy of the steam in the first condition subtract the entropy of the water in the second condition. Multiply the difference by the absolute temperature in the second condition, and subtract the product from the difference between the total heat in the first condition and the heat of the liquid in the second condition.**

The Marks-Davis tables for superheated steam give the total heat per pound of steam at 165 pounds absolute and 100 degrees superheat as 1232 B.t.u. and the entropy as 1.6269. At 155 pounds the entropy for the same total heat would be, by interpolation from the same table, 1.6333. The temperature, corresponding to 28 inches of vacuum, is 100 degrees Fahrenheit and the heat of the liquid at that temperature is 67.97 B.t.u.

All of these values can be gotten from the steam table. Performing the arithmetical operations indicated by the rule we have for the first condition:

165 pounds and 100 degrees superheat

$N_1 = 1.6929$	$t_2 = 100$		$1252.00 = H_1$
			$67.97 = h_2$
$n_2 = 0.1295$		460	$1184.03 = H_1 - h_2$
$N_1 - n_2 = 1.4974$	$\times$	$560 =$	$838.54 = (N_1 - n_2)\,T$
			345.49 B.t.u. convertible into mechanical energy.

For the second condition

155 pounds throttled from 165

$N_1 = 1.6333$			
$n_2 = 0.1295$			1184.03
$N_1 - n_2 = 1.5038$	$\times$	$560 =$	842.13
			341.9 B.t.u. convertible into mechanical energy.

This is the number of B.t.u. which a perfect engine could convert into mechanical energy working between the given limits. The falling off for the second condition is

$$\frac{345.49 - 341.90}{345.49} = 0.01 \text{ or } 1\%$$

This accords with the results of practice where turbines which do not govern by throttling, so that the full initial pressure is available, give an increased efficiency of about 0.1 per cent. for each pound of additional initial pressure.

As to the effect upon capacity, the amount of steam flowing through the first set of nozzles or guide vanes will be roughly proportional to the absolute initial pressure. The turbine, for example, with all the nozzles open or with the admission valve full open all the time would take $\frac{165}{155} = 1.065$ times as much steam with an initial pressure of 165 pounds as of 155 pounds absolute. With equal efficiency it would do 1.065 times as much work (6.5 per cent. more) with the higher initial pressure. If the efficiency is 1 per cent. better it will be

$$1.065 \times 1.01 = 1.076$$

times as much work, or 7.6 per cent. more.

Acting on data furnished by field men, the United States Geological Survey took action in March leading to the creation of water-power-site reserves in Arizona, Colorado, New Mexico, Utah and Washington aggregating 24,091 acres. The reservations are believed to contain many favorable power sites. Restorations of more than 10,000 acres of land previously withdrawn in connection with power sites were made during the month in Colorado, Idaho and Washington. This land was found upon further investigation to be not necessary to the control of power sites.

*$H_1 - h_2 \quad (N_1 - n_2)\,T_2$

Where
H_1 = Total heat per pound in initial condition;
h_2 = Heat of liquid in final condition;
N_1 = Total entropy in initial condition;
n_2 = Entropy of liquid in final condition;
T_2 = Absolute final temperature (F.° + 460).

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Transformer Connections

By Cecil P. Poole

Since no skill is required in the connection of three-phase transformers to the primary and secondary circuits and there are no two-phase transformers, the present article is confined to the connections of single-phase transformers on two-phase and three-phase circuits.

Two-phase Connections

Practically all two-phase lines are merely two single-phase lines supplied from the same source with currents which are out of step with each other to the extent of one-quarter of a cycle, or 90 electrical "degrees." For the delivery of current to lamps and other devices except two-phase motors, transformers are connected to the two lines exactly as they would be to two separate single-phase lines not related to each other, with the exception that the amount of load connected to the two station lines should be divided equally between them, as nearly as possible.

Fig. 1 shows a simple two-phase primary circuit with transformers connected to it and supplying individual secondary circuits, which are single-phase, of course. One of the transformers is represented by the conventional diagram indicating its primary and secondary windings.

Transformers can be "banked" on one of the divisions of a two-phase line exactly as in the case of a single-phase circuit. The same precautions as to instantaneous polarities, equality of size, similarity of type, etc., that were described in the explanation of single-phase work apply to two-phase connections and the same objections exist.

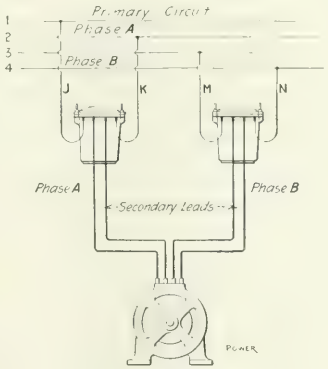


Fig. 2. Two-phase Motor Properly Connected

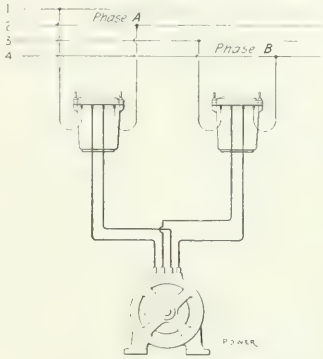


Fig. 3. Two-phase Motor and Transformers Connected with "Mixed" Secondary Leads

When a two-phase motor is to be supplied through transformers, two transformers exactly alike are used and these are connected up as shown in Fig. 2. It makes no difference, so far as the effect on the transformers is concerned, which way the leads are connected to the circuits. The leads *J* and *K* may be transposed without causing any trouble in the transformers; this is true also of the leads *M* and *N* and of each pair of secondary leads.

The transposition of any pair of leads, however, will reverse the direction in which the motor runs. For example,

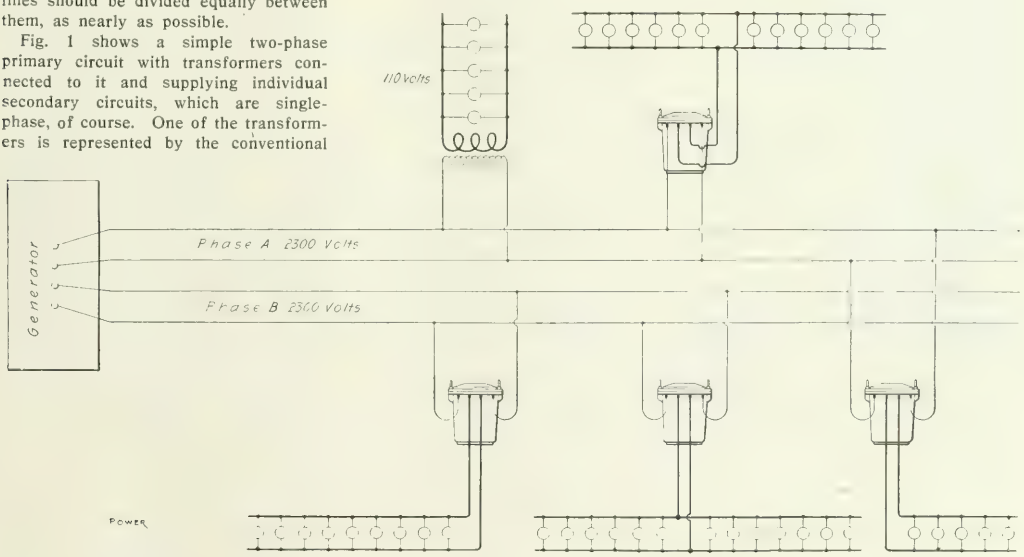


Fig. 1. A Balanced Two-phase Circuit Supplying Lamps Only

if the motor shaft turns clockwise with the connections as indicated in the diagram, transposing the wires of any pair, such as connecting *J* to the primary wire 2 and *K* to the wire 1, will cause the motor to run counterclockwise. If two pairs of leads be transposed, the direction of rotation will remain as before, because one transposition would reverse the motor and the second transposition would re-reverse it back to the original direction.

In connecting up the transformers of a two-phase motor care must be observed to put one transformer on one primary phase and the other transformer on the other phase. The same precaution must be observed in connecting the secondary leads to the motor. If the transformers should be connected up

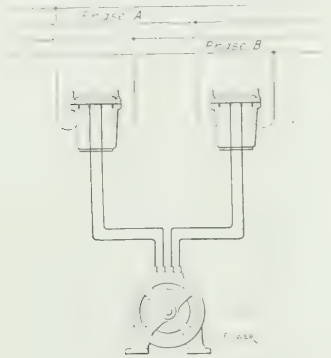


FIG. 4. TWO-PHASE MOTOR AND TRANSFORMERS CONNECTED WITH "MIXED" PRIMARY LEADS

with mixed phases, at either the primary or the secondary leads, the motor will not run. Fig. 3 shows mixed secondary phases; one lead from the "A" transformer is connected to one of the "A" terminals of the motor and the other lead to one of the "B" terminals, and the leads from the "B" transformer are similarly mixed. Fig. 4 shows mixed primary phases; each transformer is connected to both phases of the supply

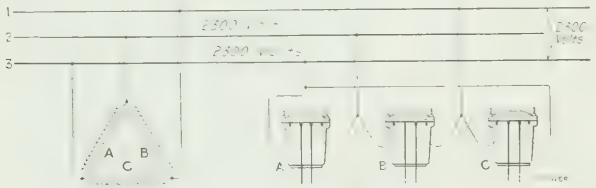


FIG. 5. DELTA CONNECTION OF TRANSFORMER PRIMARY LEADS

circuit and neither one gets the proper current for operating the motor.

It is practical to use any of the connections on either division of a two-phase system that can be used on a single-phase system, but it is seldom desirable to use any other than the simple straightforward connections shown in Figs. 1 and 2.

THREE-PHASE CONNECTIONS

There are two general plans of connecting transformers on a three-phase system: "delta" and "star." The delta connection is represented by the diagrams in Fig. 5, where the primary windings are shown at the left and the corresponding transformer arrangement and circuit connections at the right. Although this arrangement appears on paper as though the transformer windings were short-circuited, that is not true if they are properly connected, because the phase differences and momentary polarities of the electromotive forces prevent it. When the voltages of any two of the windings are in the same direction around the triangle, the voltage of the third one is opposed to them and equal to both of them added together.

The star connection is represented in Fig. 6. Only one terminal of each transformer is connected to the circuit; the other three are connected together, and this connection is called the "neutral" point of the system.

With the delta connection, the voltage

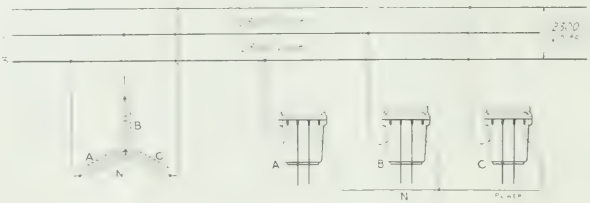


FIG. 6. STAR CONNECTION OF TRANSFORMER PRIMARY LEADS

of each transformer is that of the circuit; in Fig. 5, for example, each transformer receives 2300 volts from the primary circuit. With star-connected windings, however, each transformer receives at its primary terminals only 57.7 per cent. of the circuit voltage. For example, if the voltage between any two of the primary wires is 2300, as indicated in Fig. 6, the e.m.f. at the terminals of each transformer winding will be 1327 volts.

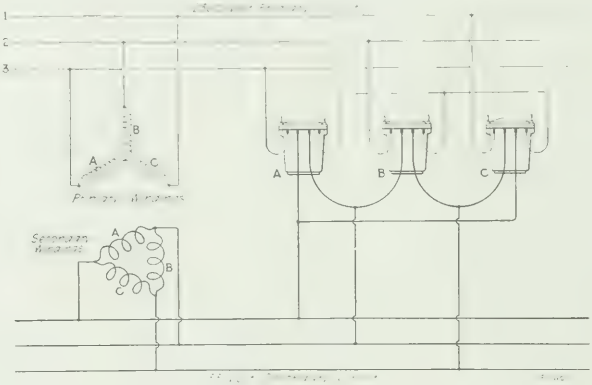


FIG. 7. DELTA-CONNECTED PRIMARY LEADS AND STAR-CONNECTED SECONDARIES; TERMINAL VOLTAGE RATIO = 57.7 × RATIO OF WINDINGS

This peculiarity of three-phase star connections—the voltage between each main and the neutral being 57.7 per cent. of the main-to-main voltage—can be made useful in some cases where two voltages are required and in others where changes in the transformer ratio are desirable. Since the same rule applies to the secondary windings, three voltage combinations are possible by merely changing the connections of the primary and secondary leads, no "taps" in the windings being necessary.

Fig. 7 shows three transformers connected to give minimum secondary voltage. The ratio of the transformer *windings* is 10 to 1; that is, the secondary

voltage of each transformer is one-tenth of the primary voltage applied to its terminals. With 2300 volts between each pair of wires of the primary circuit, the primary voltage of each transformer is 1327; this makes the secondary voltage 132.7, and as the secondaries are delta-connected in Fig. 7, this is the voltage in the secondary circuit to the motor.

In Fig. 8, both primary and secondary windings are star-connected; consequently, the *transformer* primary voltage is 57.7 per cent. of the primary *circuit* voltage, or 1327 volts, and the secondary voltage of each transformer (132.7) is 57.7 per cent. of the secondary circuit voltage, which is therefore 230 volts.

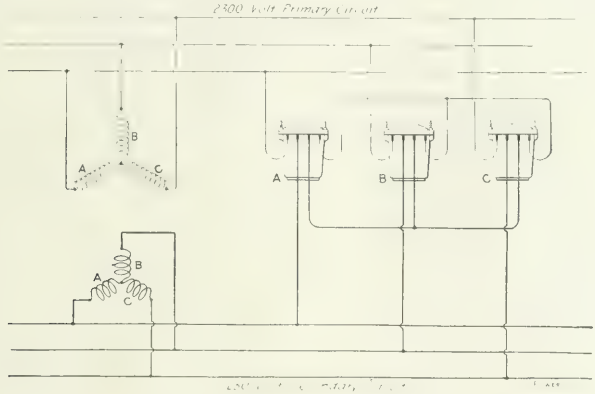


FIG. 8. PRIMARY AND SECONDARY LEADS BOTH STAR-CONNECTED; TERMINAL VOLTAGE RATIO = RATIO OF WINDINGS

Fig. 9 shows the final combination, delta-connected primaries and star-connected secondaries. The primary transformer voltage is 2300 and the secondary transformer voltage 230, but the star connection makes the secondary *circuit* e.m.f. $1.732 \times 230 = 398$ volts.

The full number of combinations just described is seldom, if ever, used in power-plant practice; it entails the disadvantage of carrying both the primary and secondary leads of the transformers through a controlling switch, and this would cause more trouble and danger than the resulting advantage is worth, outside of a laboratory or a test room. The secondary connections, however, are sometimes arranged to be changed from delta to star by means of a switch; when it happens that the transformers are near the control switch this is practical, but if the distance is great, the fact that all six of the secondary leads must be carried to the switch usually makes it impractical.

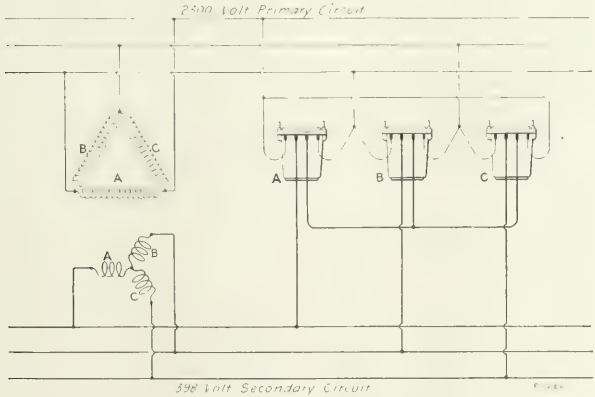
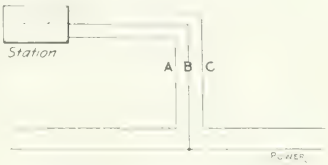


FIG. 9. PRIMARY LEADS DELTA-CONNECTED AND SECONDARIES STAR-CONNECTED; TERMINAL VOLTAGE RATIO = 1.732 × RATIO OF WINDINGS

LETTERS

Mr. Scarborough's Three-Phase System

Referring to the wiring diagram of D. W. Scarborough, in POWER of Mar. 19, I do not see how he can have his load evenly balanced. If he takes his circuits from the wires *A* and *B* and *B* and *C*, that will be using only two phases, causing the ammeter in the leg *B* to read twice as much as either *A* or *C*; the combined readings of the ammeters in *A* and *C* will be equal to the reading of the ammeter in *B*.



MR. SCARBOROUGH'S DIAGRAM

When I took charge of the plant where I am now, which is a three-phase, three-wire system, our lineman commenced connecting up by taking branch lines from the legs *A* and *B* and *B* and *C*, and the result was an unbalanced load. I then told the lineman to take branches from *A* and *C* also and thereby balanced the load on the generator.

F. M. BENJAMIN.

St. Cloud, Fla.

[Mr. Benjamin is right in his contention that Mr. Scarborough's three-phase system was not balanced. Mr. Scarborough was probably misled by the fact that the ammeters in the legs *A* and *C* indicated equal loads. For correct three-phase balance, all three ammeters must read alike. Mr. Benjamin is in error, however, in assuming that an ammeter in the leg *B* will indicate as much current as both of the others added together. On account of the phase relations, the current in the wire *B* would be only 87 per cent. of the sum of the other two currents if they were equal. That is, with 100 amperes in *A* and an equal current in *C*, the current in *B* would be about 173 amperes, if no load were connected between *A* and *C*.—EDITOR.]

The United States Geological Survey's estimates of the coal areas of Texas show that the bituminous fields known to contain workable coal cover 8300 square miles. The estimated original supply of bituminous coal in Texas is placed at 8,000,000,000 short tons. From this there had been mined to the close of 1910 a total of 20,056,941 short tons, which represents an exhaustion of approximately 30,000,000 tons, the exhaustion being one-tenth of 1 per cent. of the original supply. The supply left in the ground at the close of 1910 would be equal to 19,000 times the production of that year.

The first shipment of petroleum from the Gemsah field of Egypt was recently made, consisting of 3000 tons in a tank steamer. The Gemsah oil field is on the Red Sea.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

An Experience with an Otto Engine

By A. Ulmann, Jr.

Many an engine badly treated has given the gas-engine industry a setback due to the prejudice aroused by what seemed to be the inability of the engine to fulfill the requirements. In nearly every case these failures can be traced to ignorance and neglect on the part of operatives or to the fact that the engine has been applied to work for which it is not suited. As a further proof of these oft-stated facts, I wish to submit to my fellow readers an experience that fell to my lot.

Among other equipment that came under my charge about two years ago, was a 40-hp. German-built Otto engine using alcohol for fuel and belt-connected to a fiber-extracting machine. This engine had been giving very poor satisfaction, and apparently could not pull the load required; it stood still as much as it ran, defied all attempts to start it and consumed alcohol with the prodigality of a New Year's Eve drunk.

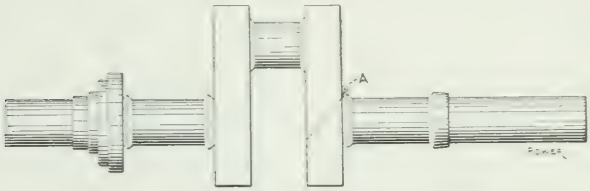


Fig. 1. Showing Where the Shaft Failed

The first thing that was noticeable was that the engine had but one flywheel in place of two, and, although the shaft stub for the second wheel ran in full sight, no one seemed to know what it was there for. The engine was "quantity governed," and when it did run the governor cam jumped back and forth like a shuttle and the speed of the engine varied about 20 per cent. In locating the cause of this trouble it was found that the inlet and exhaust valves did not open sufficiently and that the igniter worked very badly, missing about one in five explosions; also, the governor springs were so weak that the engine ran about 10 per cent. below its rated speed.

After these faults were corrected, the engine ran much better but still it would not pull the load required; the igniter still missed fire and the gases blew past the piston very badly. Then it was decided to give the engine a thorough overhauling and if possible cure the remaining defects.

Both main bearings and the crankpin bearing were rebabbitted, and an old cast-iron flywheel of approximately the weight of the missing one was bought and keyed in place. But upon taking out the piston a horrible state of affairs came to light. The piston and liner had been burned through lack of oil until their surfaces were as hard as glass and were gouged and scratched very badly. The rings were burred into the grooves so that they had to be taken out in pieces with a cape-chisel as no file would cut the burrs due to the hardening of the surface of the metal by the frequent heatings to which it had been subjected. Luckily a spare set of rings were discovered stowed away under a pile of junk in a locker.

Worst of all, it was evident that some mechanical genius while putting the wristpin into the piston had neglected to push it home so that the setscrew in the piston boss could enter the hole drilled in the wristpin for that purpose. The result was that the wristpin had backed out and come in contact with the cylinder liner, wearing two grooves in it about ⅛ in. deep and the length of the stroke.

This state of affairs, of course, in conjunction with the condition of the piston, made a new piston and liner absolute necessities. These were ordered from Germany and a piece of ⅜-in. iron plate was inserted between the crankpin bearing-box and the connecting-rod stub to lengthen the rod and thereby reduce the clearance of the engine; this gave higher compression and therefore reduced the likelihood of misfire. After cleaning everything, taking up all lost motion in the valve rods and lay-shaft bearings and tightening the governor springs, the engine was put into operation and with careful handling and lots of lubricating oil gave fair satisfaction for three months until the new piston and liner arrived.

During the interval, however, one more accident occurred to this engine. One morning about 9 o'clock I received notice that the cylinder had cracked, and making all haste to the factory I found that the water jacket had cracked along the top of the cylinder from the head end forward about 6 in. to a boss in which was threaded the outlet pipe for the water circulation. Upon removing the cylinder head the entire water jacket was found to be thickly coated with scale. Due to the vibrations of the engine, a large piece of this scale had become detached and when the circulating water came in contact with the bare iron the crack was caused by the resulting rapid and uneven contraction. This was repaired with a patch of ¼-in. iron plate held in place with a number of ⅜-in. tapscrews tapped into the water jacket. Before tightening in place a liberal coat of Smooth-On cement was applied to the cylinder beneath the patch.

Fig. 2. Showing How the Shaft Failed

This answered the purpose admirably and gave no further trouble. Needless to say, all the scale was removed from the water jacket; to do this we used hydrochloric acid and long-handled scrapers inserted in the water ports that furnish the circulation to the cylinder head.

With the new piston and liner this engine ran well and for two years it pulled a load which steadily increased, due to the demands of manufacture; although I continually asked the owners for additional engine equipment, it was never forthcoming. The engine finally could stand no more and one day the crankshaft broke as indicated at *A* in the sketch, Fig. 1. It will be evident from this sketch that the shaft embodied a very bad feature of design, namely, the sharp reëntrant angles between the bearing journals and the cranks. The metal did not show crystallization at the fracture, but the break seemed to have been

caused by an incipient crack working its way into the metal from the apex of the reëntrant angle, as indicated in Fig. 1, until the entire interior of the crank cheek was separated. The outside metal *BB*, Fig. 2, held a while and finally sheared off, as was evident from the character of the break. There was no other immediate cause for the fracture as no part of the engine had become overheated and it had run well all day, except that it had been subjected to an overload so severe that at times it nearly stopped.

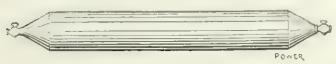
Gas Samples by Express

By G. W. Munro

Many producer-plant operators would doubtless be glad to have authoritative analyses of their gas output, but lacking both the necessary chemical equipment and technical skill, feel entirely helpless in the matter. Such may be interested in the experience herein recited.

Some time ago, the unsatisfactory operation of a gas-power plant made it necessary to fix the responsibility as between producer and engines, which were furnished by different makers. The engine specifications called for a certain minimum heat value in the gas, and these specifications had been accepted by the producer builder. The issue therefore was the quality of gas furnished, and there was no apparatus within a hundred miles for testing gas.

Rather than make another trip, I had two tin cans, holding about 2 gal. each, made as shown in the accompanying sketch. These were used to transport samples of gas for analysis, the samples being taken, the ends of the cans dipped in paraffin, the cans boxed and shipped



Holder for Carrying Samples of Gas

by express to the nearest laboratory. The samples were analyzed, the cans returned and refilled with other samples representing other running conditions, and sent back to the laboratory.

The analysis of a few samples showed that the producer was at fault and it was rejected. Before placing the order for a new producer to take its place, samples were taken from a producer already in service like the one under consideration and its suitability for the service thus practically predetermined.

Twelve samples were shipped in this manner over distances ranging from 100 to 500 miles. One shipment, misdirected, was about two weeks in reaching its destination, yet not a sample showed even a trace of oxygen, showing conclusively that no air had become mixed with the gas during shipment or handling.

For handling gas samples in this manner certain precautions are necessary. In filling the can from a pressure system the process is very simple; it consists merely in attaching one pet-cock of the can to a similar one in the gas main by a rubber tube, opening both pet-cocks and allowing the gas to flow through for some time to be sure that the air is all expelled.

The cock at the free end of the can must be closed first, of course, in order to trap the gas in the can under pressure.

In a suction plant the gas may be collected over water, first saturating the water to be used by shaking it in contact with some of the gas. Water from the scrubber, if not too dirty, should be suitable for the purpose. Great care must be exercised in making connection to the gas main to see that there are no leaks, for any leak, however small, will admit air to the sample and spoil it. A second can should be connected to the free end of the sampling can so that it may be partly filled with gas which may later be forced back into the sampling can to raise the pressure above the atmosphere. This will make the direction of any leakage outward, which results only in losing a little gas, whereas leakage inward spoils the sample.

In removing the sample for analysis, the chemist should heat the can enough to get the required sample rather than displace it with water, as the introduction of unsaturated water results in absorbing some of the carbon dioxide and thereby changing the composition of the remainder of the sample, making a check analysis impossible.

A Producer Gas Experience

By George L. Markland

Our power plant consists of a 50-hp. tandem producer gas engine, with its accompanying suction gas producer. This equipment replaced two gas engines—one of 22 hp., the other of 20 hp.—which had formerly made up our power equipment, and which operated on city gas.

When the new producer plant was installed it ran well for about six weeks, but our man, who had had no experience with producer plants, adjusted the governor until the engine was running on air regulation. As the producer gas became more or less rich, the valves had to supply a proportionate quantity of air, or backfire resulted. In other words, the governor was adjusted too close to regulate properly.

After this difficulty was overcome the question of coal became a serious one. We first arranged for a supply of pea coal, for which we paid $4.35 a ton. This coal clinkered badly in the producer. Consequently we had to keep the men overtime until 7 or 8 o'clock at night to break out the clinker with sledgehammers. This kind of treatment threatened to destroy the generator, so we invited five different companies to send us each a ton of coal and explained to them the conditions the coal had to meet.

One lot of coal made a beautiful fire, but absolutely no gas. Another kind gave fine gas, but ran into clinker as hard as flint. Finally one company suggested that we try a ton of buckwheat coal which had given excellent satisfaction in other producer plants and which cost only $3.50 a ton. This coal we are still using, and while we have some clinker, the quantity is small and causes us practically no trouble. The coal is delivered to us in 15-ton lots and runs uniform.

In the third place we had to experiment with the time of charging the generator with coal. At first we charged it every two hours, but found that it was frequently necessary to use city gas in order to carry the engine over the period of charging. By charging the generator every two hours we saved stoking through the top and prevented the clinker forming, but the method proved to be impracticable, as the engine sometimes dropped its speed and stopped entirely during the time we were charging the generator.

We have found it advisable, therefore, to charge it at night when our factory closes and to charge it again in the morning at 7 o'clock after raking the fire and poking it down.

We have had, too, some amusing experiences, alarming at the time they happened, but always proving to be very simple after investigation.

In the first place one of the men who erected the engine left a ½-in. nut in the governor case, and after we had been running the machine about four days this nut interfered with the governor balls, broke the stem and shut down the engine. After searching an hour and a half, the trouble was discovered and remedied.

A month later, after the governor had been adjusted so closely that we were depending on air regulation by valve, we got a terrific backfire because of the bad mixture, which turned the material in the dry purifier upside down, and again the engine stopped. In this case we started the engine on city gas and later in the day discovered the trouble.

Of course, all these things affected the men in the shop so that they began to look upon the plant in the nature of an experiment, but anyone who reads these experiences will realize that all of our troubles were due to neglect, ignorance, or carelessness. Our chief difficulty has been to overcome the prejudice among our employees.

The engines which were displaced by the present equipment produced bills with the city gas company which averaged $120 a month. The cost of labor was

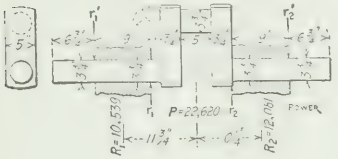
about $25 a month. The labor cost on the present equipment is $45 a month, but the cost for fuel is only $30. In addition we charge up 60c. worth of kerosene a month for the new plant. We found it necessary to soak the governor cage in kerosene all night, replacing it in the morning before starting the plant; this gave much better speed regulation. The other expenses incident to the power equipment are the same now as when the old equipment was in operation, except that the fire insurance rate has been increased because of the installation of the producer plant. The additional monthly expense for this is $6.50. We are arranging, however, to make changes in other parts of the plant which will reduce the insurance enough to offset the increase mentioned. Even with this increase, we are saving $62.90 a month by using the producer gas equipment.—*Factory.*

CORRESPONDENCE

Weak Crankshafts

The casualty insurance reports printed in POWER from time to time are of much value to those interested in engine design. The writer is sometimes called in at the "inquest" in similiar cases and it seems remarkable that there are so few failures and practically no cases of human injury when some of the commercial constructions are considered. Too many large engines have failed because the design was based on successful practice with small engines where requirements and service were the easiest possible.

Herewith is shown a sketch of a ridiculously weak shaft used in a 12x 16½ illuminating-gas engine with 70 lb. compression. It is necessary to retard the ignition of this engine to such a degree that the maximum pressure is limited to 200 lb. per square inch in order to get



smooth operation of the engine. If the engine is adjusted for power and economy of fuel, the springing of the shaft and bed is alarming. Many of these engines are in use and every one of the larger ones is a menace to life and property. Their shaft failures are so frequent that some provident owners keep a shaft on hand constantly, some engines having broken three shafts so far.

Assuming reactions at centers of the main bearings as stated on the sketch, the maximum fiber stress at the center of the crankpin on starting would reach practically 24,000 lb. per square inch.* Assuming a terminal inertia of reciprocating parts of 60 lb. per square inch of piston area, the unit stress when up to speed would reach $\frac{140}{200}$ of 24,000, or 16,800 lb. per square inch.

When these engines are new and the bearings are snug, these stresses are of course never reached as the deflection causes the reaction points to move inward closer to the inner edges of the bearings as at r_1 and r_2. This localizes the bearing pressures, the babbitt is soon beaten out and the reaction points spread until finally the great deflection and the recurring of heavy stresses cause fatigue and ultimately fracture of the shaft.

ALOF ALOFSEN.

Philadelphia, Penn.

* Let P = Maximum pressure on crankpin
R_1 = Reaction at center of bearing B_1
R_2 = Reaction at center of bearing B_2
J = Section modulus at center of crankpin
M = Bending moment, inch-pounds
S = Unit stress at center of crankpin

Then $P = 12^2 \frac{\pi}{4} \times 200 = 22{,}620$

$$R_1 = \frac{10\frac{1}{2}}{22} P = 10{,}539$$

$$R_2 = \frac{11\frac{1}{4}}{22} P = 12{,}081$$

$$J = 0.098 \times 3\tfrac{1}{2}^3 = 5.168$$

$$M = 11\tfrac{1}{4} \times 10{,}539 = 123{,}830$$
$$10\tfrac{1}{2} \times 12{,}081$$

$$S = \frac{M}{J} = 23{,}960$$

Curing a Leaky Exhaust-pipe Joint

The owners of a gas engine installed for driving the machinery in a fairly large factory were troubled by leakage of spent gas from the exhaust connections of the engine into the room where the engine was situated, which was so serious that it had to be remedied.

FIG. 1. ARRANGEMENT WHICH CAUSED LEAK

Examination showed that the cause of the trouble was due to the inflexibility of the exhaust pipe and muffler. These can be more clearly understood by reference to the two sketches herewith shown. As originally installed, the muffler was buried solidly in the floor and connected, by means of a fairly long pipe with a bend in it, to the exhaust outlet of the engine, the joint being made by means of a flange screwed on the end of the pipe. (See Fig. 1.) It will be evident that with this arrangement the muffler formed a rigid support for one end of the pipe and the flange the support for the other end. When the engine was under full load, the escaping exhaust expanded the pipe to such an extent that severe strains were thrown on the joint, causing it to become leaky. Eventually the matter was remedied by making the muffler movable and putting it on rollers, as shown in the second sketch.

To do this the pit in which the muffler was placed was enlarged both in width and in depth and beneath the muffler were placed two small pieces of gas pipe which served as rollers. With this arrangement, the muffler moved forward on the rollers when the pipe expanded and when

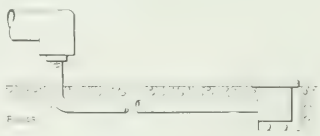


FIG. 2. MUFFLER ON ROLLERS

the engine was shut down it rolled back to its old position. This effectually remedied the trouble, which had threatened to become very serious from the owner's point of view.

J. A. SEAGER.

Bristol, Eng.

Erratic Speed Variation

Irregularity of speed in gas engines is usually caused by either faulty governor mechanism, overheating or misfiring. The two last-mentioned troubles are easily detected and their correction may or may not be a simple matter. It is the first-named fault with which this short letter deals.

The pins and joints in a governor mechanism may have become so worn by continuous use that they are slack in one position and tight in another, thereby causing irregular governing. The larger components of the governor mechanism, however, may also cause trouble, as will be seen by the following experience which recently came under the writer's notice. A twelve-year old gas engine of about 4 brake horsepower was fitted with a hit-and-miss governor. This engine would run steadily for a time, then suddenly speed up or die down about 10 per cent. of the normal rate of speed, maintaining the abnormal speed for a few minutes at a time.

After much thought and guessing it was found that the camshaft, the bearings of which had become considerably worn, would shift along axially, and the thrust from the skew-wheel on the crankshaft would force the bevel gear driving the vertical governor spindle tight against the gear on the latter with which it meshed. This caused the governor spindle to bind, and the governor then lost its sensitiveness. Fitting thin washers between the boss of the skew-wheel on the side-shaft and the camshaft bracket cured the trouble.

JOHN S. LEESE.

Manchester, Eng.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Hot Water Heating for Institutions*

By Ira N. Evans

It is almost the universal practice for such large institutions as hospitals, colleges and asylums of various kinds, comprising a group of buildings, to provide the heating from a central plant as a matter of both low first cost and economy of operation. Hot water by forced circulation is particularly well adapted to this class of work, and when the magnitude of the plant is over 10,000 sq.ft. of radiation the operating cost should be less than for a steam system on a proper layout. The larger the plant the less in proportion will be the cost of heaters and pumps to the whole.

Inasmuch as this method of heating was first applied to shops and factories in connection with the use of exhaust steam from the power plant, many have assumed that it was more or less limited to this class of work. The applications are just as varied as those of steam heating with the added advantage that the water system, having a variable temperature of the medium independent of the power of circulation, has the same economy in the use of steam, whether exhaust or live steam is used on the system.

This point is of especial importance in connection with this class of work, as the power load is generally greatest at night, when lighting is required for a comparatively few hours, and during the day the exhaust steam is insufficient for the heating requirements. College work to a great extent is discontinued during the summer months and the regular terms comprise the months of the heating season.

It may be readily seen that if the heating medium is maintained at a nearly constant temperature of 212 deg. instead of a variable temperature averaging 160 deg. throughout the heating season, that the live-steam requirements would be greater if the power load did not furnish sufficient exhaust steam. If automatic heat control is provided and maintained in proper working order, the steam system will be economical, but will be high in first cost and maintenance.

If pressures are varied below atmosphere it will mean work for the vacuum pump to overcome the air leaks of the piping and larger mains will be required for the same output. These vacuum pumps use about 125 lb. of steam per horsepower-hour and the drain traps provided for removing condensation from the steam mains at distant points are a continual source of waste and expense, especially where grades are such as to interfere with a gravity flow to the power house.

A steam system designed to operate economically on live steam under pressure is uneconomical for exhaust operation or impossible, and one arranged to operate on exhaust at low pressure is uneconomical when operated on live steam due to the constant temperature and pressure impressed.

It is of frequent occurrence in large steam plants where the distances are great that the condensation requires a considerable length of time in returning

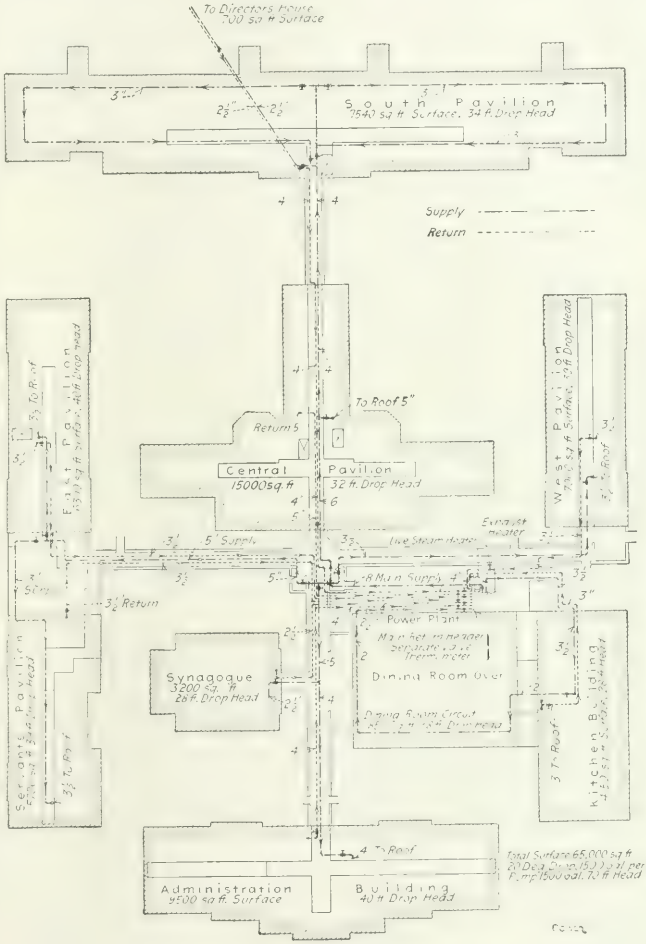

To Directors House 700 Sq ft Surface
South Pavilion 1540 sq ft Surface, 34 ft Drop Head
Supply
Return
To Roof 5"
Return 5
Central Pavilion 15000 sq ft 32 ft Drop Head
East Pavilion 1530 sq ft Surface, 41 ft Drop Head
West Pavilion 700 sq ft Surface, 19 ft Drop Head
5" Suppl.
Live Steam Heater
Exhaust Heater
Main Supply
Return
Power Plant
Manifold in Engineer's Office
Synagogue 3200 Sq ft 28 ft Drop Head
Dining Room Over
Dining Room Circuit
Servants Pavilion
Kitchen Building
Roof
Total Surface 65,000 sq ft
Administration 4500 sq ft Surface
Building 40 ft Drop Head

Fig. 1. Arrangement of Mains with Single Flow and Separate Returns

*Copyrighted 1912, by Ira N. Evans, consulting engineer, 156 Broadway, New York City.

to the power house, and make-up water has to be provided in the meanwhile for boiler feed. The condensation returning afterward remains in the return tank, if it is large enough, and loses its heat or is passed into the overflow and is wasted.

These difficulties are more serious where live steam is used for heating than when there is ample power to provide exhaust steam. They are entirely absent in the operation of the hot-water system as no steam is taken outside of the power house and the water temperature from the entire plant can be perfectly regulated to suit outside weather conditions without automatic heat control.

The water system with the same amount of radiation as for steam at 212 deg. will average about 160 deg. throughout the heating season and only about 6 per cent. of the time will maximum temperature be required.

If the steam system averaged 212 deg. and the water 160 deg. with the same radiation and the rooms 70 deg. in both cases, the steam transmission would be at the rate of 212-70 deg. and the water at 160-70 deg., or 142 and 90 deg. respectively. This would mean that $^{90}/_{142}$ or only 63 per cent. of the heat used in a steam system would be required for a water system. The condensation from traps and losses from the use of pumps and receivers, which may amount to 15 per cent. more, are additional. It is also clear that when the power load would be sufficient in the case of water in all moderate weather the steam system would require the addition of live steam continuously except at the time of the peak lighting load when the heating requirements would be minimum.

As a rule, the heating engineer seldom considers the heating load in moderate weather in temperate climates, but bases all calculations on the maximum load at 212 deg. This is caused by the inability to vary the temperature of the medium to any extent when considering the low-pressure steam system. As the exhaust steam is considered insufficient no attempt is made to increase the economy of the engine equipment for power. Carried to an extreme in some cases, this causes a surplus of exhaust steam after the plant is in commission.

In a water system the average load is the most important as the engines might be compounded with economy and vacuum carried in some cases. No steam is taken outside the power house as live steam is utilized in the live-steam heater with gravity return to the boilers, and the exhaust is used in the exhaust heater under partial vacuums, if conditions are favorable. If the exhaust from the circulating pump, with a steam consumption of not over 26 lb. per horsepower-hour, is used in the heating system, the friction of the water in the mains will about produce heat sufficient to balance that lost by the pump.

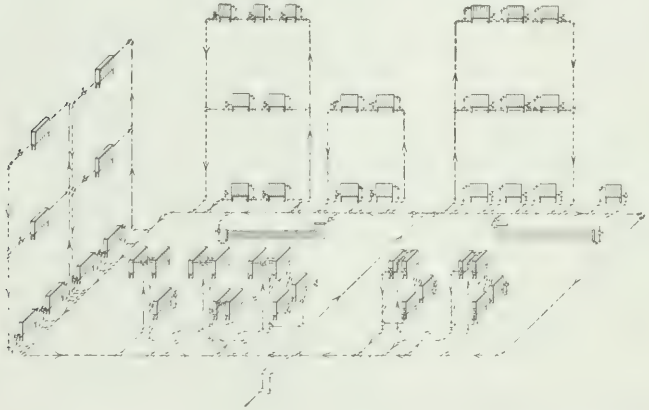
Regardless of any claim to the contrary, any group of large buildings will require continuous operation of the heating system on account of the extra boiler power necessary for intermittent heating. There is no economy in fuel in intermittent operation.

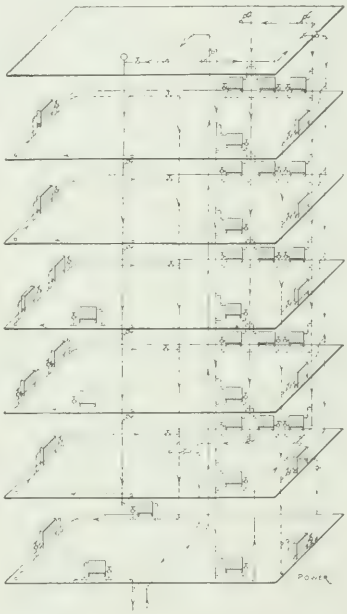
There are two methods of handling the live steam for heating on a hot-water plant of this character. First, when the exhaust steam just balances the heating in moderate weather, and power is operated 24 hr. per day, requiring live-steam operation at long intervals only, the condensation may be discharged through a high-pressure trap into the steam space of the exhaust heater. The pump or other method of removing the condensation of the exhaust heater will answer for both.

Second, where the live-steam heater is required a considerable portion of the time, as would occur when there was little or no power at night, the regular method of returning the condensation to the boiler by gravity should be employed. In most plants of this character there will be a surplus of exhaust steam during the peak of the lighting load a few hours in the evening. Under these conditions the exhaust heater, if the load is of sufficient magnitude, should be arranged to carry some vacuum. With the outbound water at 160 deg., 20 in. of vacuum could be carried and the heating system used as a condenser to the extent of its capacity. This would decrease the steam consumption on the power units so that possibly no more exhaust steam would be furnished under the greater power load than would exactly balance the heating requirements, or the same amount as when there was less power load and no vacuum.

In case the peak lighting load should be somewhat in excess of the heating requirements, a small cooling tower could be used to help out and regulate the vacuum on the heating system. If the heating required 5000 lb. of steam per hour at 160 deg. and 20 in. of vacuum and the power load furnished 8000 lb. at the same vacuum, a cooling tower for 3000 lb. of steam would enable vacuum to be carried on the entire peak load and the condensing capacity of the heating system, or 5000 lb., would be obtained for nothing.

In summer, the lighting load and the number of hours duration are so re-





FIGS. 2 AND 3. TYPICAL ARRANGEMENTS FOR PIPING AND RADIATION IN BUILDINGS

duced on this class of plant that the small condensing equipment would be sufficient.

In most institutions of this class considerable mechanical ventilation is required, especially in the lecture rooms of colleges. One of the mistakes of the heating engineer has been over-ventilation of these buildings or the installation of a system so designed as to compel operation by combining it with the heating. It is well known that when outside air is heated to 70 deg. for ventilation or 120 deg. for heating and ventilation combined, the fuel requirements increase two or three times over heating by direct radiation. The operating force, not having any endowment to purchase coal, finds a big saving in fuel by eliminating the ventilation when possible. Undoubtedly many doctors have condemned a system of ventilation that has ceased to be operated.

It is a great mistake to heat buildings with steam, and a hot-water system for the direct surface. This is expensive and entirely unnecessary as both the indirect and direct surface can be operated from the same hot-water mains on a properly designed system. This does away with the duplication of the heating systems and all fans can be operated by motors supplied by current from the main engines which furnish the exhaust for heating.

In designing a hot-water plant the mains should be arranged so as not to bypass and require local regulation of the flow. This can be accomplished by balancing the distance as well as the friction heads on the different circuits, and making the direction of flow the same on the return and supply mains as in Fig. 4. In this layout, due to the proper sizing of pipes, the drop in head across the mains is nearly the same throughout the circuit, regardless of the drop in head along each main.

ers for the same difference in temperature. It also brings the outboard temperature of the water nearer to that of the exhaust steam; this is a great advantage in steam consumption for power where turbines are used under partial vacuum. It also makes the system as a whole more responsive to regulation and facilitates changes in water temperature to suit outside weather conditions.

In most institutions live steam at comparatively high temperatures is required the year round; in colleges for chemical laboratories and in hospitals and asylums for sterilizing, cooking, boiling, kitchens, laundries, etc. This corresponds to steam in a factory for maunfacturing purposes and for economical operation should be on a separate line from the heating.

Fig. 1 shows a layout of mains for a large city institution. The buildings are fed from a single 8-in. supply main which is reduced as the connections are

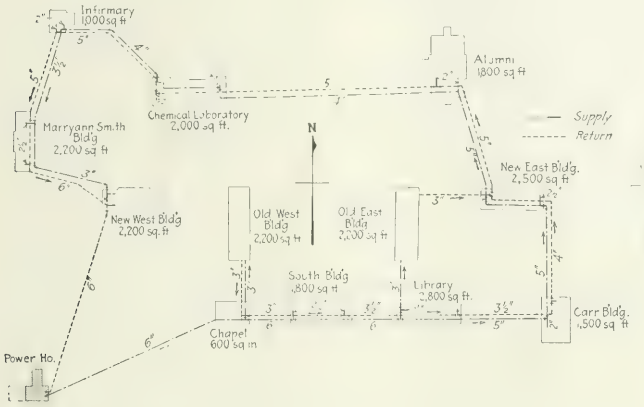


Fig. 4. Supply and Return System

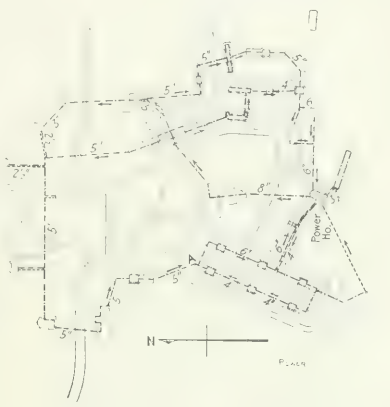


Fig. 5. Single Pipe Shunt System

with a hot-water system operating on low temperatures entirely by indirect radiation. If low water temperatures are actually used, the cost of both installation and possibly the operation will be excessive, to say nothing of the bulk of the apparatus. If the cost is reduced, it will result in high temperatures of water and uneconomical engine operation, in some cases requiring live-steam operation entirely in extreme weather.

The proper way to design a system of this kind is to furnish slightly less direct radiation than required for the radiation of walls and glass, and provide fresh air at 70 deg. in such quantities as will give the number of occupants the proper supply. The rooms should be arranged so that the air supply can be discontinued when unoccupied and the temperature maintained by the direct radiation only.

Some hospitals have been arranged with a separate system of ventilation

The balancing of distances may be omitted on small jobs where low velocities and comparatively large mains are used, but it is absolutely essential where high velocities and long distances are involved to obtain the proper discharge without individual regulation by means of lock stop valves.

As the radiation of the mains is an important item, every inch that the mains are decreased in diameter reduces the surface $3^1/_7$ times and the extra power is compensated for in the heat due to the friction returned to the water. The only limit to this is the use of the single-stage pump which will not produce heads of much over 125 ft. with economy. If the distances are long, the drop in head per 100 ft. will have to be reduced. The drop in temperature should not be over 20 deg., and 15 deg. is better. This brings the average temperature lower throughout the system and increases the transmission of both radiation and heat-

taken off. Each building has an overhead system with single 1¼- or 1½-in. risers, the radiators being connected in shunt as shown in Fig. 3. Several arrangements of piping to the radiator are shown. Attention is called to the method of connecting radiators in the basement with the return main on the ceiling. Fig. 2 shows the arrangement of the south pavilion for buildings under four stories, with radiators connected to a single main on the basement ceiling.

Figs. 2 and 3 show nearly all the basic methods of arranging piping for this class of building. Each building has a separate return to the header at the pump, Fig. 1, with a valve and thermometer. This arrangement allows of no complication in figuring the drop in friction head and the valves at the header provide additional regulation besides that of the water temperature. The live-steam heater is arranged with a trap to discharge into the steam space of

the exhaust heater as it will not be needed except in extreme weather as the power plant is operated 24 hr. per day. The exhaust heater is arranged to utilize the vacuum on the engines due to the temperature of the water. Where indirect radiation is provided for ventilation it would be good practice to connect it to the general supply main with a separate return or to a separate loop with the indirect stacks connected in shunt.

Pipe coils are most efficient and will be found cheaper in the long run than cast-iron indirect surface for this work. The cast-iron surface may cost slightly less, but the testing and replacing of a very few broken sections will soon make up the difference.

The separate return mains will not cost any more than the large single return outside of the covering, and the advantage in central regulation obtained will more than pay the extra cost. This is appreciated when it is necessary to vary the circulation in the buildings due to the changes in direction of the wind.

Hot-water domestic service may be handled by a separate system of piping in the same manner as the hot-water heating with circulating pump exhaust and live-steam heaters. This service, however, should never be connected to the heating mains or any water be allowed to be displaced in the heating system proper, as the piping will deteriorate. On the hot-water service galvanized or brass pipe should be used, on account of the displacement of water. It will be found that much smaller mains may be used and considerable economy of first cost and operation effected by this arrangement of the domestic service and the circulation will be positive and sure.

The expansion tank should be placed in the engine room and handled by air pressure with automatic air traps at all high points.

Fig. 4 shows a group of isolated buildings with a supply and return. This plant is actually laid out with a 6-in. main with radiation shunted in the different buildings. It was taken as an example to show the advantage in cost of the single-pipe system. With a velocity of 7 or 8 ft. per second in the 6-in. main, sufficient drop in head is obtained in the length of each building to produce circulation without lock-stop valves or chokes.

Fig. 5 shows a large home in the West with two single-flow branches, the main 8-in. branch being divided twice. This particular system requires adjusting valves at several points which could be avoided with a different layout. Where the 4-in. supply enters the return from the other section at *A*, the head in the supply is liable to be greater than that in the return and tend to reduce the velocity unless carefully regulated by valves at *A*. Circuits should be laid out separately so that there will be as little complication in the calculation of the drop in head as possible.

All of the plants shown can be installed for less cost than a steam system of the same capacity, when all items of cost are considered and the cost of operation will be about 30 per cent. less for heating and power combined. The requirements of institution heating are somewhat different from central town heating, as the latter, to be successful, must be wholly a byproduct plant with ample exhaust steam which must be utilized to the best advantage. The institution, on the other hand, has a fixed heating load to be provided for whether there is power or not. Due to the comparatively small amount of power required, they are in many cases live-steam plants a large portion of the time.

Many steam plants of this class are arranged to operate on vacuum systems with very low pressures when they would be more economical in first cost and operation if pressures above atmosphere were used on the distant buildings, only the near-by buildings being operated on exhaust steam. Due to the live- and exhaust-steam heater arrangement on the forced hot-water system and independent power of circulation, the same system of mains would be used with equal economy, whether exhaust- or live-steam operation were under consideration.

A vacuum on a live-steam system is an unnecessary expense in both first cost and operation, due to the requirements of the vacuum pumps and the reduction of the operating pressure through a reducing valve to nearly a constant pressure and temperature. The greater volumes of the steam at low pressure require larger mains for the same output, thus increasing the radiation losses in transit.

The repairs are greater on the pressure system, but the pressure to remove the air from the system and the ability to vary the pressure and temperature to suit outside weather conditions is not to be overlooked when coupled with smaller mains and less radiation.

One of the future fields of hot-water central heating will be in connection with high-class real-estate developments, the central plant furnishing domestic water, hot and cold, lighting and heating. This particular application involves the same character of load as for institution heating, the heating requirements being somewhat in excess of the power if the entire section is included. The method of obviating this difficulty is to furnish power to the whole section and only furnish heating for a portion to the extent of the power installation in boilers. The portion heated can be located so as to make it more desirable, and higher prices can be obtained for these lots. While the development is acreage, mains can be installed and operation started before the streets are turned over to the city, thus avoiding any conflict with terms in the franchises of existing public-service companies.

If alleys are reserved through the centers of the blocks and not turned over to the city as streets, the pipes can be laid through these on a single-pipe circuit, and, except for crossings, they can be kept out of streets altogether. Electric wire and water pipes could all be laid in the same conduit at comparatively small expense.

Afterward, the plant could be sold to the public-service company at a good profit, as it could operate the entire plot for heating to better advantage, shutting it down entirely in summer and providing lighting service from the outside mains.

With their mains from the main power station to absorb surplus current when the heating load was large, and to supply current when the heating load was small, they would have a distinct advantage over the developers. Where it would not pay the developers to extend the heating to the entire section, it would pay the public-service company to do so as it could utilize the surplus current at all times and eliminate the use of live steam on the heating system.

Cause of Pump Racing

In the issue of Apr. 2, Mr. Moulton's pump is caused to race by the condensation of steam in the heating system creating a partial vacuum and so holding the water back from the pistons. Vapor thus forms in the pump cylinder and, of course, the pump races and pounds until the system is up to atmospheric pressure again.

A remedy would be to install a large vacuum breaker, shut the steam off the system slowly or to stop the pump until the vacuum is broken.

M. J. MANN.

Ipswich, Mass.

With the use of superheated steam, it has become necessary to efficiently cover the high-pressure portions of the turbine cylinder with nonconducting material, because the metal on the inside of the cylinder in contact with the steam becomes hotter than that on the outside, especially at the edges of flanges and ribs. The inside tends to expand, and this expansion is resisted by the colder metal on the outside. As a consequence, if the temperature difference is great enough, the metal will be distorted and perhaps strained beyond its elastic limit. For this reason the design of the ribs should be carefully considered, the thickness of metal throughout the structure being kept as uniform as possible.—*Mechanical Engineer.*

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

The Technical Graduate and the Power Plant

Soon the technical schools throughout the country will be turning out another year's output of graduates into the engineering field. Many of these men have exaggerated ideas of their own worth as embryo engineers and will therefore seek positions with little hard work and which they believe will be short cuts to leading executive positions. As a result of this self-conceit, many will never get farther than the drafting board or the office desk that handles routine work—all small salaried jobs.

In the central-station and power-plant engineering field splendid opportunities are open for technical men. A broad practical experience is necessary, and this necessarily means starting as a helper in an operating plant. While the work is hard, steady and dirty, the hours often long, the pay small and promotion sometimes slow, the man's experience is growing and his usefulness increasing.

To meet the modern demand for high efficiency and scientific refinement, industrial executives in the future must put men in charge of their power plants who not only have the broadest technical and business training but who also have the widest practical experience. They will always be ready to pay well for a first-class man to take charge of these plants, as such a man may easily save his salary many times over in a year by the improved economies he may be able to effect.

When improvements or enlargements of the plant are to be undertaken, the chief engineer is usually consulted and his ideas given careful consideration before any changes are made. In most cases, he plans all such undertakings himself, even to making the designs. In looking over the lists of the members of the American Society of Mechanical Engineers, one is surprised to find that so great a number of the older and more prominent men in the field of steam engineering have at one time in their career served as operating engineers. It is therefore apparent that other and better positions of responsibility become available for the operating man as his experience increases.

It can be seen that in power-plant engineering there is a great and promising field of growing importance for the young technical graduate who likes machinery and is not afraid of a few years of hard work. Why should not such work be chosen in preference to apprentice courses with some large manufacturer of a single line of products?

Steam Mains and Steam Traps

So many articles have appeared in technical journals from time to time that one is surprised to note the number of mistakes that are still made in the design of new power plants. As a rule, these mistakes are due to the inexperience of designers with power-plant operation and many errors would be avoided if a competent operating man was called in and allowed to check over the plans. While sufficient provision is usually made for stresses and a proper material specified for the pipe and fittings, on the other hand, many of the operating features are frequently overlooked.

A serious accident occurred in a plant of recent construction in this country. The steam main was provided with tees to some of which the boiler leads connected on one side while the engine branches connected to others, all these connections being made on the sides of the main steam pipe. The drain system to the steam traps consisted of one-inch pipe connected to drilled holes on the bottom sides of these tees. The traps were standard and of a reputable make, but had very small water capacity. The power load fluctuated badly at times and one day the boilers commenced to foam. As no part of the steam lines could act as a catch-basin, the water went over direct to the engines; a disastrous wreck was the result.

If an operating engineer had checked this piping design, he would have prob-

ably made all the steam connections on the top of the header instead of at the sides, and would have provided a sufficient number of drip chambers or separators, to which traps could be connected. These devices would have mitigated to a considerable extent the possible damage to the engines if the boilers were to foam.

In operation, all steam traps should be inspected once every watch, though some operating engineers feel that they have made a satisfactory inspection when they tilt a trap or open its bypass and hear it discharge; almost any trap should discharge when treated in such a manner. The proper method is to provide an outlet on the discharge pipe so that the engineer can open it and actually see the trap discharge under working conditions at least once on his watch; this outlet will also serve as a telltale on leaky trap valves. The steam trap is a useful and serviceable adjunct to the steam plant, but it must be watched closely and kept in perfect condition at all times to make it give satisfactory service.

The steam-piping system is the main artery of the steam plant, so to speak, and the greatest care must be taken in its design and operation.

Byproduct Gas Producers

Most American inventors of gas producers have endeavored to produce tar-free gas from bituminous coal. Some have been quite successful and others have produced gas heavily charged with lampblack which has proved very troublesome around gas producers and engines.

The United States Steel Corporation is said to be producing coke at one of its new plants for almost nothing, the gas and byproducts practically paying for the coal and the cost of the coking process.

A large Mond gas-producer plant has been in operation at Dudley Port, near Birmingham, England, for several years, from which the byproducts, tar and ammonium sulphate, are recovered and sold. The gas is distributed through mains over a considerable area and practically no trouble has been experienced with tar in the distributing system, doubtless due to the careful and thorough washing given the gas after it leaves the producer.

It has always been objected that such a process could not suceed in America, owing to the difficulty of disposing of the byproducts. The American farmer is as progressive as any in the world and when he learns the advantages of ammonium sulphate as a fertilizer, the demand for this material will increase rapidly. The plant of the Steel Corporation already referred to seems to have no difficulty selling its byproducts.

Tar, usually considered a waste, may prove one of the most valuable of all the byproducts. The success attained in Europe in using tar-oils and even moderately thick tar as a fuel for Diesel engines opens up a wide field for this waste product.

European engineers have shown what can be done in developing new processes and utilizing new equipment, as, for instance, the producers and Diesel engines already mentioned. It is now time for an American engineer to design and build a producer-gas central station for one of our large cities. The byproducts from the bituminous coal could be saved and the ammonium sulphate marketed. The tar would be treated and such portions saved as can be used for fuel for Diesel engines. These engines could be located in substations and used only to carry the peak loads. The residue of heavy tar substances might be put into stills and subjected to a cracking process until all that remains is a coke which could be returned to the producer. Such a process would make available many cheap grades of bituminous coal and would entirely stop the smoke nuisance.

While many difficulties would have to be overcome, none are beyond our present engineering ability. Such a plant would probably occupy much larger floor space than a corresponding steam plant, but it could be located outside the city proper and the gas piped to large holders near the power plants. These plants could be located to minimize the distribution losses. By providing Diesel engines for peak loads, the central producer plant could operate steadily at nearly one hundred per cent. load factor. This economy of operation, with the high thermal efficiency of the gas engine itself, should make such a station highly profitable, even though the first costs may exceed those of a steam-turbine power plant of equal capacity.

The problems involved in such an undertaking are exceedingly intricate, but the possibilities warrant very careful consideration by our engineers.

Natural Sources of Energy

While the coal strikes abroad have wrought much hardship, one benefit at least has accrued. Attention has been directed to conserving fuel supplies and developing other natural sources of energy.

In its recent report—which is not complete—the British Science Guild shows that while almost unlimited supplies of energy exist, they are for the most part still inaccessible.

For instance, Sir William Ramsay estimates that a ton of radium contains four hundred and sixty thousand times the energy of a ton of coal, but the uranium ores of the entire world would not assay over five hundredweight (the equivalent in energy of one hundred and twenty-five thousand tons of coal); therefore, radium has no commercial importance as a fuel.

Another British physicist says that energy can be obtained by boring a hole in the earth twelve miles deep, where the normal temperature is two hundred and seventy-two degrees Centigrade, but we have no facilities for drilling the hole.

As an alternative to coal, the possibilities of oil were also discussed, says our British contemporary, *The Mechanical Engineer*. The present production of crude oil is barely sufficient to provide one-sixth of the power now developed by coal.

Sir J. J. Thomson last year estimated that, shining from a clear sky, the sun sends energy to the earth at the rate of seven thousand horsepower per acre, but in all attempts to utilize it only a small fraction has been recoverable as work.

Increased economy in the conversion of the heat energy of coal into mechanical work and reduction in the present wastes of fuel will defer the exhaustion of our coal resources, but hardly in proportion to the ever-increasing demand for power. That the coal supply will ultimately fail seems inevitable. Meanwhile, we must look for other means of obtaining power, and the present most promising are water and wind power. The development of these now will conserve the coal and must, with other possible sources of power that may become available, eventually take its place.

Efficiency of Joints in Boiler Shells

By H. L. Strong

Calculations showing how to figure the efficiencies of both lap and butt joints with single, double and quadruple riveting.

To many engineers, calculating the safe working pressure of a boiler shell or drum is a complex and difficult operation, especially that part of it which deals with the efficiency of riveted joints. Perhaps it is a little difficult to keep in mind all of the formulas, but if the principles governing the calculations are thoroughly understood, it then becomes a matter of ordinary arithmetic.

Assume a boiler shell the greatest internal diameter of which is 60 in., constructed of ½-in. steel having a tensile strength of 60,000 lb. per square inch. What will be the bursting pressure and the safe working pressure with several styles of riveted longitudinal seams? First, employ the usual formulas for bursting and safe working pressures; that is,

$$\frac{T.S. \times t \times E}{R}$$

and

$$\frac{T.S. \times t \times E}{R \times F.S.}$$

respectively, where

$T.S.$ = Tensile strength of material in pounds per square inch of cross-section;

t = Thickness of material in inches or fractional parts thereof;

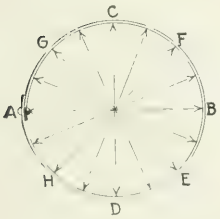


Fig. 1

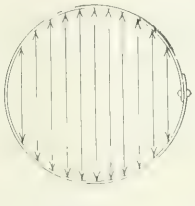


Fig. 2

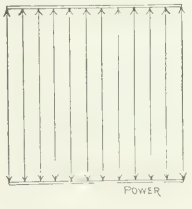


Fig. 3

Representing Pressures in Boiler Shell

E = Efficiency of longitudinal seam, expressed in decimals;

R = Greatest internal radius in inches;

$F.S.$ = Factor of safety.

Assume a factor of safety of 5 in all cases. Substituting the proper values in the formula the problem becomes

$$Bursting\ pressure = \frac{60{,}000 \times 0.5 \times E}{30}.$$

Just why the radius enters into the formula instead of the diameter or circumference may be seen by reference to Fig. 1, which represents a single-riveted ring, and as the pressure of liquids and gases is equal in all directions, it follows that pressure acting on the inside of the ring must be conceived as radiating from the center as indicated by the arrows. The weakest point in the ring is the riveted joint; therefore consider the strain on the ring at that point as at A, although it is equally great at B or at any other point. To understand how the pressure acts to pull the ring apart, one must conceive of the pressure acting equally in opposite directions, as indicated by the arrows above and below the horizontal line in Fig. 1. The forces acting at C and D are at right angles to the horizontal line and are therefore exerting their full effect, while those at E, F, G and H are acting at an angle and are less effective.

Fig. 2 represents the same action, and is perhaps easier to understand. The total effective forces represented in either Figs. 1 or 2, acting on the whole circumference, are equivalent to those shown in Fig. 3, which represents the unit pressure acting equally over two flat surfaces equal in length to the diameter of the shell. The boiler in the example under consideration is 60 in. in diameter; therefore force tending to pull the shell apart along the plane AB is equivalent to the pressure acting in opposite directions on two flat surfaces 60 in. long on which this tendency is resisted by the metal in tension at both A and B. But as only one side of the ring or the point at which it is riveted is being considered, only one-half of this surface should be taken. Hence the radius is used instead of the diameter; that is, dividing the strength of the joint in pounds per inch of length by 30 will give the pressure in pounds per square inch, which will theoretically cause it to fail.

If the ring were equally strong at all points it would require

$$\frac{60{,}000 \times 0.5}{30} = 1000\ lb.$$

pressure per square inch to burst it.

To determine the efficiency of the joint or, in other words, just how strong the ring actually is, the American Boiler Manufacturers' rules for designing riveted joints may be employed. In these

d = Diameter of rivet hole = $2t$ (or approximately twice the thickness of the thinnest plate);

e = Distance from rivet hole to edge of plate = $1\frac{1}{2}d$;

P = Pitch of rivets = $3d$;

V = Distance between adjacent rows of rivets = $\frac{1}{2}P$;

l = Lap of plates = P.

The following symbols in the formula for calculating riveted joints are those commonly employed:

$T.S.$ = Tensile strength of plate;

t = Thickness of plate;

d = Diameter of rivets after driving;

P = Pitch of rivets on row having greatest pitch;

a = Cross-sectional area of rivets after driving;

S = Strength of rivets in single shear;

S' = Strength of rivets in double shear;

N = Number of rivets in single shear;

N' = Number of rivets in double shear.

Fig. 4 represents a single-riveted joint. In calculating riveted joints, a strip of

Fig. 4. Single-riveted Lap Joint

plate equal to a unit length of joint is considered; that is, a strip equal to the distance from center to center of two rivets on the row having the greatest pitch. This should not be confused with the 1-in. ring previously considered.

In the present example of a single-riveted joint, let the pitch be 2¼ in. Then this length of solid plate has a tensile strength of

$$60{,}000 \times 0.5 \times 2.25 = 67{,}500\ lb.$$

which is the same thing as

$$P \times t \times T.S.$$

Call this quantity A. Let the rivets be $\frac{15}{16}$ in. or 0.9375 in. in diameter, after driving, and the net section of plate between the rivet holes is

$$2.25 - 0.9375 = 1.3125$$

and

$$1.3125 \times 0.5 \times 60{,}000 = 39{,}375\ lb.$$

the strength of plate between the rivet holes. This is equivalent to

$$(P - d)\ t \times T.S.$$

Call this quantity B. The shearing strength of the rivets per square inch of cross-sectional area may be taken as follows:

Iron rivets in single shear	38,000 lb.
Steel rivets in single shear	42,000 lb.
Iron rivets in double shear	70,000 lb.
Steel rivets in double shear	78,000 lb.

The shearing stress on the rivets, of course, tends to cut them in two, and in a properly designed joint the rivets should be able to withstand as great a stress as the net section of plate between the rivet holes.

Referring to Fig. 4, it will be seen that there is one-half of a rivet between the pitch lines on each side, which is equivalent to one rivet in a unit length (2¼ in.) of joint. A ⅞-in. rivet has a cross-sectional area of 0.6903 sq.in., and

$$42{,}000 \times 0.6903 = 28{,}992.6\ lb.$$

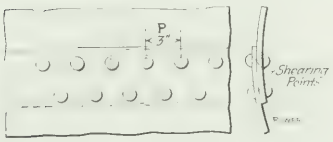


FIG. 5. DOUBLE-RIVETED LAP JOINT

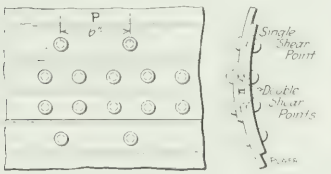


FIG. 6. DOUBLE-RIVETED BUTT-STRAP JOINT

the shearing strength of one rivet in single shear. Designate this as quantity C. Now,

$A = 67{,}500$;
$B = 39{,}375$;
$C = 28{,}992.6$.

Evidently, the joint will fail by shearing the rivets as C has the smaller value. Therefore, dividing C by A gives 0.429, or 42.9 per cent. as the efficiency of the joint.

Such a joint is unsatisfactory. The riveting is 10,375 lb. weaker than the net section of plate between the rivet holes and the efficiency of the joint is low. The boiler would burst at an internal pressure of

$$\frac{60{,}000 \times 0.5 \times 0.429}{30} = 429\ lb.$$

per square inch, and dividing 429 by 5 gives 85.8 lb. as the safe working pressure.

Now try double riveting with ⅞-in. rivets (after driving), and 3-in. pitch. Fig. 5 represents this joint, and the only difference between the calculations for this joint and those for the single-riveted one is that there are two rivets in single shear instead of one.

Now, using the regular formula,

$$A = P \times t \times T.S. = 3 \times 0.5 \times 60{,}000 = 90{,}000\ lb.$$

$$B = (P - d)\ t \times T.S. = (3 - 0.9375) \times 0.5 \times 60{,}000 = 61{,}875\ lb.$$

$$C = N\ S\ a = 2 \times 42{,}000 \times 0.6903 = 57{,}895\ lb.$$

Again, C is the smallest value and

$$\frac{C}{A} = \frac{57{,}895}{90{,}000} = 0.643 \text{ or } 643\ per\ cent.$$

which is the efficiency of the joint. The safe working pressure is

$$\frac{60{,}000 \times 0.5 \times 0.643}{30 \times 5} = 128\ lb.$$

The joint is not satisfactory yet; hence a double-riveted, double butt-strap joint as indicated in Fig. 6 may be tried. In this joint there are two rows of rivets on each side of the joint proper, but those on one side only are considered. The inner row has a 3-in. pitch and the rivets are in double shear, the plate tending to cut them at two points, as indicated.

The outer row has double or a 6-in. pitch, and the rivets are in single shear. The pitch of the inner row of rivets does not enter into the calculations, merely

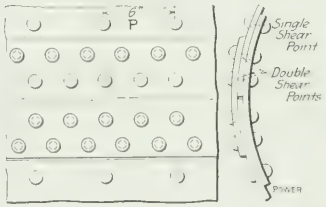


FIG. 7. TRIPLE-RIVETED BUTT-STRAP JOINT

the number of rivets and rivet holes and their size. Also, as the combined strength of the straps is greater than that of the shell plate, they are not considered. Using ⅞-in. rivets, as before (after driving), and applying the formula

$$A = P \times t \times T.S. = 6 \times 0.5 \times 60{,}000 = 180{,}000\ lb.$$

or the strength of the solid plate in a unit length (6 in.) of joint.

$$B = (P - d)\ t \times T.S. = (6 - 0.9375) \times 0.5 \times 60{,}000 = 151{,}875\ lb.$$

or the strength of the plate between the rivet holes on the outer row.

$$C = N\ S\ a + N'\ S'\ a = (1 \times 42{,}000 \times 0.6903) + (2 \times 78{,}000 \times 0.6903) = 28{,}992.6 + 107{,}686.8 = 136{,}679.4\ lb.$$

the shearing strength of one rivet in single shear in the outer row, and two rivets in double shear in the inner row.

$$D = (P - 2d)\ t \times T.S. + N\ S\ a = (6 - 1.875) \times 0.5 \times 60{,}000 + (1 \times 42{,}000 \times 0.6903) = 123{,}750 + 28{,}992.6 = 152{,}742.6\ lb.$$

the strength of the plate between the pitch lines minus the two rivet holes on the inner row, plus the shearing strength of one rivet in single shear on the outer row.

It will be seen that a joint of this style might fail by breaking the plate between the rivets on the outer row (quantity B), by shearing the rivets in both rows (quantity C), or by breaking the plate along the inner row of rivets and shearing the outer row (quantity D). In this case the joint will fail by shearing all of the rivets, as C has the least value. Therefore

$$\frac{C}{A} = \frac{136{,}679.4}{180{,}000} = 0.759 \text{ or } 75.9\ per\ cent.$$

which is the efficiency of the joint. The plate is still stronger than the riveting, but the safe working pressure would be

$$\frac{60{,}000 \times 0.5 \times 0.759}{30 \times 5} = 151.8\ lb.$$

Now consider a triple-riveted double butt-strap joint as shown in Fig. 7. The only difference in calculating this one and the previous one is that in Fig. 7 there are four rivets in double shear instead of two, and in getting the quantity D the possible point of failure is taken as

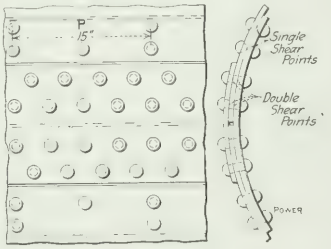


FIG. 8. QUADRUPLE-RIVETED BUTT-STRAP JOINT

along the second or middle row of rivets instead of the inner row. Then

$$A = P \times t \times T.S. = 6 \times 0.5 \times 60{,}000 = 180{,}000$$

the strength of the solid plate in a unit length (6 in.) of joint.

$$B = (P - d)\ t \times T.S. = (6 - 0.9375) \times 0.5 \times 60{,}000 = 151{,}875$$

the strength of the plate between the rivet holes on the outer row.

$$C = N\ S\ a + N'\ S'\ a = (1 \times 42{,}000 \times 0.6903) + (4 \times 78{,}000 \times 0.6903) = 28{,}992.6 + 215{,}373.6 = 244{,}366.2\ lb.$$

the shearing strength of one rivet in single shear on the outer row plus the shearing strength of four rivets in double shear on the middle and inner rows.

$$D = (P - 2d)\ t \times T.S. + (N\ S\ a) = (6 - 1.875) \times 0.5 \times 60{,}000 + (1 \times 42{,}000 \times 0.6903) = 123{,}750 + 28{,}992.6 = 152{,}742.6\ lb.$$

as the strength of the plate between the pitch lines on the middle row of rivets plus the shearing strength of one rivet in single shear on the outer row.

This style of joint may fail by breaking the plate between the outer row of rivets, by shearing all of the rivets or by breaking the plate along the middle row of rivets and shearing the outer row. The riveting now exceeds the strength of the solid plate, as will be seen by comparing quantities *A* and *C*. A more efficient joint would be secured by spacing the rivets farther apart. Quantity *B* being the smallest, the joint would probably fail by breaking the plate along the outer row of rivets. Therefore

$$\frac{B}{A} = \frac{151{,}800}{180{,}000} = 0.845 \text{ or } 84.5 \textit{ per cent.}$$

and the safe working pressure is

$$\frac{60{,}000 \times 0.5 \times 0.845}{30 \times 5} = 169 \textit{ lb.}$$

per sq.in.

So far, none of the joints considered have been of correct design for the case at hand, but they have served to demonstrate the methods of calculating their efficiencies and also by guessing at the efficiency may possibly lead to unsatisfactory results. A standard quadruple-riveted, double butt-strap joint will now be laid out, as shown in Fig. 8, with the following particulars:

Rivets, $\frac{15}{16}$ in. (after driving).
Pitch of outer row, 15 in.
Pitch of second row, 7½ in.
Pitch of two inner rows, 3¾ in.

$$A = P \times t \times T.S. = 15 \times 0.5 \times 60{,}000 = 450{,}000 \textit{ lb.}$$

the strength of the solid plate in a unit length (15 in.) of joint.

$$B = (P - d)\ t \times T.S. = (15 - 0.9375) \times 0.5 \times 60{,}000 = 421{,}875 \textit{ lb.}$$

the strength of plate between rivet holes on the outer row.

$$C = N\ S\ a + N'\ S'\ a = 3 \times 42{,}000 \times 0.6903 + (8 \times 78{,}000 \times 0.6903) = 86{,}977.8 + 430{,}747.2 = 517{,}725$$

the shearing strength of three rivets in single shear on the outer and second rows plus the shearing strength of eight rivets in double shear on the third and inner rows.

$$D = (P - 2d)\ t \times T.S. + N\ S\ a = (15 - 1.875) \times 0.5 \times 60{,}000 + (1 \times 42{,}000 \times 0.6903 = 393{,}750 + 28{,}992.6 = 422{,}742.6 \textit{ lb.}$$

representing the strength of plate between the rivet holes on the second row plus the shearing strength of one rivet in single shear on the outer row.

This joint will probably fail by breaking the plate along the line of the outer row of rivets, although the quantity *D* is but slightly greater than the quantity *B*. The efficiency of the joint is therefore

$$\frac{B}{A} = \frac{421{,}875}{450{,}000} = 0.9375 \text{ or } 93.75 \textit{ per cent.}$$

and the safe working pressure is

$$\frac{60{,}000 \times 0.5 \times 0.9375}{30 \times 5} = 187 \textit{ lb.}$$

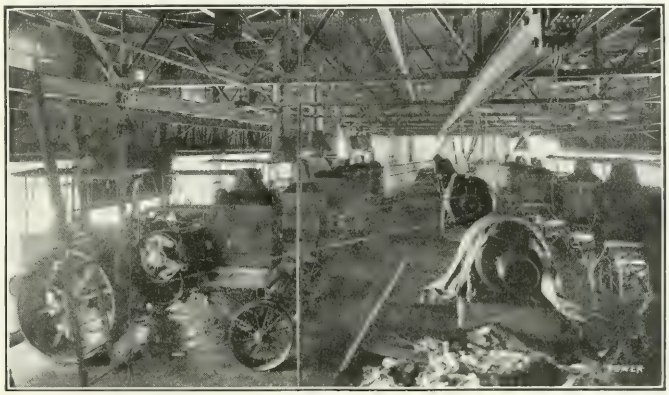
per sq.in.

In the last two joints, failure would probably occur by breaking the plate along the line of the outer row of rivets. This is usually the case with properly designed joints, and from this fact may be derived a short rule for the efficiency of joints which may be useful if used with judgment. The rule is to simply divide the strength of the net section of the plate between the two rivet holes on the outer row by the strength of the solid plate in a unit length of joint; in other words, find quantity *A* and quantity *B* and divide the latter by the former.

Generating Power as a Byproduct

By Edward K. Hammond

In the plant of the M. Rumely Co., La Porte, Ind., an interesting method has been adopted for securing power as a byproduct which serves as a material aid to the output of the regular power plant.



Traction Engines under Test

The "oil pull" tractors manufactured by this company—which comprise self-contained power units especially designed for such agricultural pursuits as plowing, hulling and threshing—derive their power from kerosene, and after the completion of each machine, it is subjected to a test of at least 48 hours' duration before being shipped. During this test run, the expedient of belting the tractors to electric generators has been adopted so that the power developed may be utilized for industrial purposes.

The illustration shows a group of "oil pull" tractors running in the company's test shed and the method of arrangement is easily understood. The elevated platform running through the center of the shed has the electric generators so mounted upon it that 11 tractors may be tested on either side. Since the plant was placed in operation, there have been six or more of these tractors running under test at all times developing an average of between 180 and 200 kw. This output would, of course, be insufficient to meet the power requirements of the entire factory, but as it is obtained without any extra expense for fuel, it is the means of effecting a considerable saving.

The regular power plant at the Rumely works is essentially a Nordberg installation. The equipment consists of two 19 and 36 by 36-in. cross-compound units, equipped with the Nordberg patent long-range cutoff valve-gear. They are run condensing and are direct-connected to 500-kw. Fort Wayne direct-current generators running at 120 r.p.m. A 32 and 32 by 14-in. duplex steam-driven jet condenser provides for the exhaust from the engines and also for the operation of a 1500-cu.ft. compressor which supplies air to the tools in the shops at 100 lb. pressure. The boilers are in a separate building, the equipment consisting of a battery of six Atlas hand-fired boilers. Coal and ashes are handled by a C. W. Hunt industrial track and car equipment.

March Coal-land Values Reach $6,442,820

In its classification and valuation of public coal lands, the United States Geological Survey acted on 1,398,371 acres in March. Of these, 368,484 acres were appraised as "coal land" by 40-acre tracts, valued at $6,442,820. There were also classified as coal lands, but the price not fixed, 16,404 acres, while 401,668 acres were classified as "noncoal."

Restorations during the month of lands classified either as coal or noncoal amounted to 801,137 acres, and were distributed through Colorado, Montana, North Dakota, South Dakota and Utah. New withdrawals of 597,234 acres were made in Utah.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

New Valve Affects Economy

The accompanying indicator diagrams were taken from the steam cylinder of a 12x14-in. air compressor using a throttling governor and fitted with a plain slide valve. The machine had been running about seven years and during this time had never been indicated. As the compressor was too small for the work required of it, and ran at very high speed, all the bearings seemed to pound

DIAGRAM FIG. 1

at once, although they were kept keyed up as closely as possible.

In an attempt to stop the noise, I decided to take some diagrams; Fig. 1 is a sample, and shows the point of cutoff to be at about three-quarters stroke and a terminal pressure of about 23 lb. I tried changing the eccentric, but while I could obtain an earlier cutoff, the compression was excessive, so I decided to make a new valve having an extra outside lap to give earlier cutoff. The exhaust lap could not be decreased as the exhaust cavity was as wide as it could be made and still prevent steam blow-

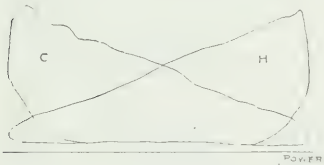


DIAGRAM FIG. 2

ing through from the steam port to the exhaust port.

After the new valve was put in, diagram No. 2 was taken, which shows the cutoff to be about one-half stroke with a fairly good compression. The terminal pressure was about 12 lb., which was a great deal with the exhaust steam blowing to the atmosphere.

The bad pound in the bearings was gone and the machine ran as quietly as could be expected from an air compressor.

In figuring the reduction in coal consumption due to this change, the diagram, Fig. 1, figured 50.5 hp. and the steam consumption at 37 lb. per horsepower-hour.

Fig. 2, which was taken at a little higher speed, showed 55.6 hp. and the steam consumed was 33.2 lb. per horsepower-hour as calculated from the diagrams with allowance made for condensation, etc.

As the result of this change a saving of nearly $200 per year in fuel costs was realized, with the additional comfort of a better running engine.

J. C. HAWKINS.

Hyattsville, Md.

Ignored the Engineer's Advice

No. 1 engine, shown in the accompanying illustration, was giving trouble due to wear; it had been in service about 40 years. The engineer suggested installing an alternating-current generator direct-connected to No. 3 engine and operating the shops with motor drive, thus eliminating No. 1 engine. This was possible as the latter was used only intermittently and the load on No. 3 was much below its rated capacity.

The central-station solicitor knew the conditions in this plant and was successful in influencing the management to use central-station current to do the work of engine No. 1, quite contrary to the engineer's suggestion.

After this service had been used for a short time the management discovered that it was costing them $6 more per week for power than before the change was made. Complaints brought the central-station experts to view the situation, and they recommended the discharge of the assistant engineer, saying one man could handle the plant. As it was over 200 ft. from engine No. 3 to engine No. 2, it will be realized that one man could not properly attend to the plant. He is doing his best, but despite his efforts the cost of power to the concern increases rather than diminishes.

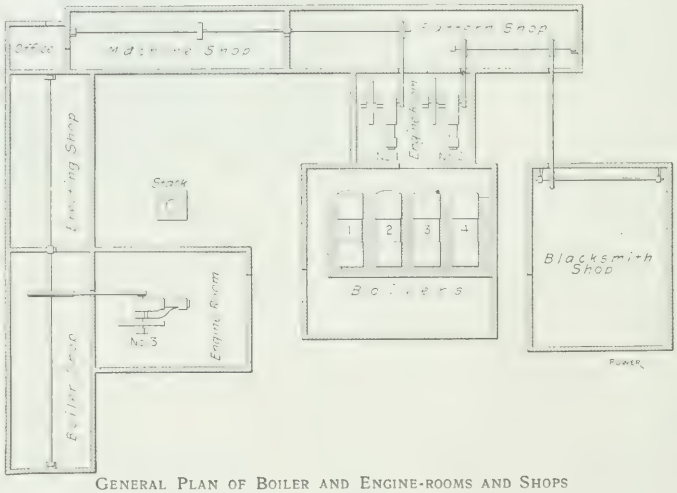
Such failures serve to show that the central station does not always meet its obligations.

W. V. FORD.

Norwich, Conn.

Knowledge Is Power

The lack of proper records is undoubtedly one of the chief reasons why so many isolated-power plants have been shut down and why others have not been installed. An engineer need never fear the closing down of his plant if he can



GENERAL PLAN OF BOILER AND ENGINE-ROOMS AND SHOPS

prove it is a paying investment. The argument that the central-station solicitor will use the records to close down the plant is seldom tenable. In many cases they do not use the recorded data, but take advantage of the lack of it.

Sometimes it is very difficult to get complete records, as where they require instruments which the owner refuses to purchase. But if the engineer will record all data available and show the owner

their advantages, he will usually be able to get what he needs.

Furthermore, every chief engineer should make his engine room a training school for engineers. This is a point that cannot be too strongly emphasized. The successful business men of today are those who have been able to get efficient work out of their employees, and the only way to do this is to have the employee know the "how and why" of his occupation.

The day of trade secrets is past. Engineers should get over the jealousy that seems to exist between themselves, and be free to ask and answer questions.

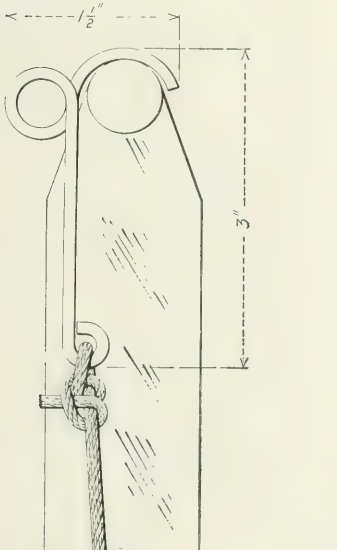
I would like to see published in POWER more copies of engineers' records.

C. L. JOHNSON.

Newark, N. J.

Drum Cord Attachment

The plain hook shown in the accompanying illustration is the simplest and most satisfactory attachment for the drum cord of a steam-engine indicator in high-speed work I have ever known. This is made from a piece of soft steel wire



SHOWING ATTACHMENT OF REDUCING LOOP

of about No. 13 gage. The hook starts out with a comparatively shallow curve, for convenience in applying. At the back of the jaws a ⅜-in. handle is looped in, and the wire then runs straight down and terminates with a suitable eye bent over at the end. The completed overall dimensions of the hook are about 1½x3 in.

The illustration shows the hook in operation, hanging on the pivot of the pendulum blade, with the cord running down under a pin or screw on the pendulum and then leading over to the indicator itself. This blade pin is located between the crosshead and the pivot of the pendulum, in a position giving the desired reduction of motion. To adjust the length of the cord, place the hook and cord as shown, with the string passing unfastened through the eye, and gradually tighten the string until the indicator drum safely clears all stops; then fasten the cord with a tight double half-hitch.

This attachment is operated entirely by one hand. To hook up the indicator, grasp the "loop" or handle of the hook between the thumb and index finger; draw the cord out taut and under the pin of the pendulum, then swing the hand upward and hook over the pendulum pivot, or upon a second pin of the blade near the pivot, as shown. To unhook, the reverse operation is gone through and the cord is hung out of the way, yet conveniently, by hooking over the pivot from the other side, with the string hanging free.

The actual operation is quickly done and can be performed with ease under the most trying conditions of running.

J. W. TAYLOR.

Massillon, Ohio.

The V-Thread on the Bolt

I have a great admiration for the genius who first conceived the idea of the thread on a bolt, but can the conditions be improved? Many a man has tried to make a half-inch nut with a 12-pitch thread affiliate with a 13-thread bolt, or *vice versa*. It started beautifully, and then it put on the brakes; he pulled harder; then he pulled too hard. Next, he got another wrench, and stuck a chisel in behind the head of the bolt to keep it from turning. On reversing the nut, some of the thread on the bolt was stripped off; then he had to hunt another bolt or the dies.

V-thread bolts, nuts, taps or dies, set-screws and cap-screws are things of the past. U. S. Standard thread eliminates the half-by-twelve thread, and lets the ⅞-in. size have it, which is perfectly fair and proper. The ⅞-in. is a good honest size, which has never been appreciated, but should be, by having a thread of its own.

The manufacturers have decided not to make any more V-thread taps and dies except by special order, but in a number of catalogs I find listed the V-thread bolts and nuts and it must be specified if the other is wanted.

The U. S. Standard thread will also eliminate the ⅞-in. oversize bolt that has been such an enemy all this time.

When this matter is fully straightened out, it is my opinion that the nut manufacturers should be made to standardize the nuts; then a lot of capital will not be tied up in dozens of different-sized wrenches in orded to meet existing conditions.

L. F. BROWN.

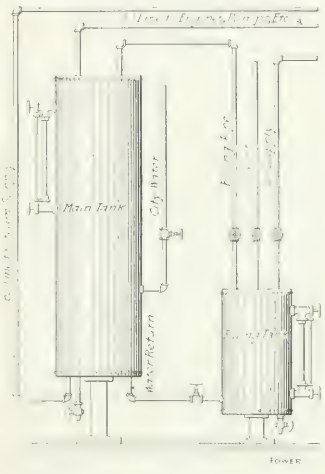
Winston-Salem, N. C.

Remodeled Oiling System

In our plant there is an oiling system designed as shown in the accompanying illustration.

It had been installed with the plant some ten years ago, but had never been put in operation until a short time ago, when we made some changes in the piping and method of operation. The result is very gratifying.

At the opening marked "city water" in the illustration, now used only as a



ARRANGEMENT OF OILING SYSTEM

filler, a ¾-in. steam line not over 5 ft. long was connected and was the only provision for the admission of live steam; it is very evident that there was not much chance for condensation in such a line.

A ⅜-in. line was run from a steam supply at the far end of the engine room and connected to the bottom of the tank, and a small tank was rigged up as a filler and connected to the oil tank by the top and bottom connections with the valves. The small tank was connected with the oil-supply room with a provision for filling it by gravity after being emptied of water.

There is no trouble with the system now, care being taken to keep the large tank full and cool at all times, and considerable saving has been effected, to say nothing of the added convenience by the use of the remodeled system.

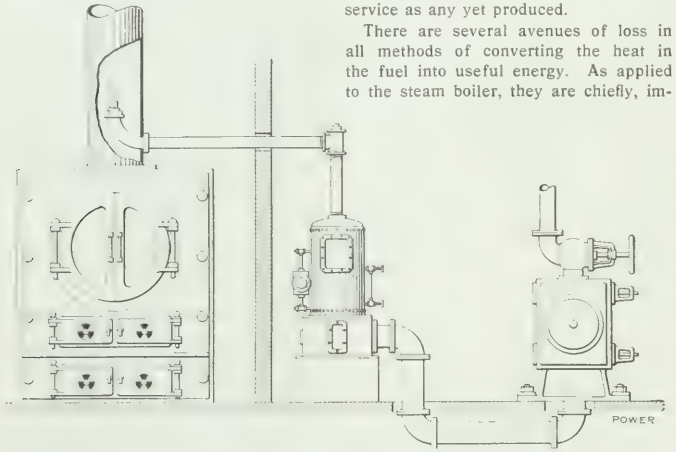
EDWARD T. BINNS.

Philadelphia, Penn.

Avoiding a Shutdown

During a high wind, the smokestack of a small flour mill was blown down, leaving a piece at the base about 14 ft. high still standing.

As this mill was in a small country town, it would take at least a week to get a new stack, so it was up to the engineer to figure out a way to keep the mill going until the new stack arrived. He was experienced in traction engines, so it did not take him long to think of the scheme shown in the illustration. He piped the exhaust steam from the engine into the base of the stack and placed an elbow on the end of the pipe so as to discharge the steam straight up the center of the stack, and screwed a bushing into this elbow in order to increase the draft. Of course, this put considerable back pressure on the engine, but it kept the plant running.



EXHAUST STEAM ASSISTING DRAFT

CHARLES FENWICK.

Wapella, Can.

Return-Tubular Boilers

In selecting a steam generator, if floor space, head room or other limitations which make imperative the use of any one type are not imposed, there are few definite data of performance for guidance beyond the many claims of those interested either in manufacture or sale, or possibly others who wish to justify their particular choice. These conditions cause many purchasers to rely upon the reputation of the builder and to follow to a large extent the suggestions as to installation and appurtenances that tend to surround the tests and operation with the most favorable conditions.

These circumstances have led, through the efforts of the builders, to the favorable reputation attained by the water-tube boiler throughout the engineering world. That wonderful results in economy and performance have been accomplished with this type cannot be denied. In view of the foregoing, the general tendency has been to credit water-tube boilers with being in advance of the other and more common forms, especially the horizontal tubular boiler. This, however, is not altogether borne out by the facts. As developed today in the United States and built by the hundreds of reputable manufacturers, the horizontal tubular boiler, equipped with the same appliances and settings usually afforded the other type, is equally as reliable and efficient a steam generator for certain classes of service as any yet produced.

There are several avenues of loss in all methods of converting the heat in the fuel into useful energy. As applied to the steam boiler, they are chiefly, imperfect combustion, imperfect transmission of the heat units to the water, and radiation from the settings and furnace walls. The first of these losses is corrected by proper firing and furnace arrangement, until a minimum is reached that is possible in one type as much as in another. The second loss, evinced by high stack temperature, is common to all types. The final temperature of the gases upon leaving the boiler must necessarily be in excess of that of the steam and water contents, and to make this temperature a minimum is the aim of all good engineers. The many divisions in which the products of combustion pass through the tubes of the horizontal tubular boiler form an admirable means of giving up the heat contents to the surrounding water. The final heat loss in this, as well as other types, is usually modified by the use of economizers or other preheating apparatus. As the loss by radiation from the walls, settings and exposed portions of the shells or drums is common to all, no comparison is needed.

In stability of operation, the odds are mainly in favor of the tubular type; the large body of water at a high temperature will continue the regular generation of steam over short periods of imperfect or irregular firing or sudden fluctuations in steam demand in a manner possible only in a generator of large water capacity.

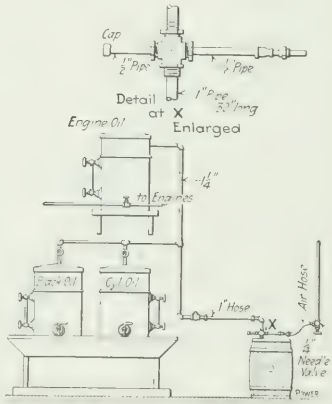
One of the broadest and most frequent claims made by those favoring the water-tube type is its immunity from disastrous accident as compared with boilers of the shell type. Records do not entirely corroborate this, however, for many serious tube failures have occurred in water-tube boilers. Furthermore, it must be remembered that failures of shell boilers have led to a development of construction in which many of the older weaknesses have been eliminated. Among these are improvements in seam efficiency, weldless braces, increased accessibility for cleaning purposes and better structural materials, and the evolution in these appears to have kept pace with present-day requirements.

W. J. SMITH.

Portland, Ore.

Compressed Air Oil Lift

In any factory or mill where compressed air is available and there is a considerable amount of oil or other liquids to be taken from barrels and transferred to tanks or other receptacles, the device shown herewith will make a very useful adjunct to the engine room.



PIPING FOR AIR LIFT

It is simple in construction and can be made in a short time (with the exception of a special bushing, which requires lathe work) by anyone familiar with pipe tools. The accompanying sketch shows the construction plainly, also the method of using the device in our power plant.

Care should be taken not to open the air valve too suddenly, especially when pumping cylinder oil, which is generally heavy and hard to move. It is best to let the cylinder oil stand in a warm place for a day or two before attempting to pump it out. A ¼-in. needle-valve on the air line should be used, but an ordinary valve will do if the attendant is careful.

A. R. MUNZER.

Middletown, Ohio.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Pump Diagrams

The efficiency of the pumping plant described by Frank Willis in the Feb. 20 issue is so low that there must be some user of steam other than the compound duplex pump from which the diagrams were taken.

The capacity of the water cylinders of the pump, at a pumping speed of 33 strokes per minute, neglecting slippage, is

$$\frac{6\frac{1}{2}^2 \times 0.785 \times 22\frac{1}{2}}{1728} \times 2 \times 33 \times 60 = 1710 \text{ cu.ft.}$$

per hour. The average pressure pumped against is 350 lb. per square inch, or 50,400 lb. per square foot. Hence the work done is

$$1710 \times 50{,}400 = 86{,}184{,}000 \text{ ft.-lb.}$$

per hour, which is equivalent to 43.5 hp.

The oil burned as fuel averages 63 gal. per hour. Since oil of 15.6 deg. Baumé weighs 8.01 lb. per gallon, the weight of the oil used is 504.6 lb. per hour. Assuming that the oil has a heat value of 18,500 B.t.u. per pound, the heat supplied to the boilers is

$$504.6 \times 18{,}500 = 9{,}335{,}100 \text{ B.t.u.}$$

per hour; hence the mechanical equivalent of the heat supplied in the oil is

$$778 \times 9{,}335{,}100 = 7{,}262{,}708{,}000 \text{ ft.-lb.}$$

per hour. Thus the overall efficiency of the plant is

$$\frac{86{,}184{,}000}{7{,}262{,}708{,}000} = 1.18 \text{ per cent.}$$

Expressed in other terms, the duty of the plant is

$$\frac{86{,}184{,}000}{9.335} = 9{,}232{,}200 \text{ ft. lb.}$$

per 1,000,000 B.t.u. supplied in the fuel. Prof. Denton, in testing the Laketon pumping engine (*Trans.*, A. S. M. E., Vol. 14), using oil as fuel under the boilers, obtained a duty of 101,117,000 ft.-lb. per 1,000,000 B.t.u., corresponding to a plant efficiency of 13 per cent. Thus, even after making allowance for differences between actual running and test conditions, Mr. Willis' plant shows a low efficiency.

A calculation of the diagrams given shows that the work done in the high-pressure steam cylinder is 22.2 hp., and in the low-pressure cylinders 36 hp., a total of 58.2 hp. Thus the mechanical efficiency of the pump is

$$\frac{43.5}{58.2} = 74.7 \text{ per cent.}$$

The steam consumption of the pump can be calculated from the displacement of the high-pressure steam cylinders, since the diagram shows that steam is admitted throughout the entire stroke at a pressure of about 45 lb. per square inch. This displacement is

$$\frac{16^2 \times 0.785 \times 22\frac{1}{2}}{1728} \times 2 \times 33 = 172.8 \text{ cu.ft.}$$

per minute. Since steam at 45 lb. pressure weighs 0.139 lb. per cubic foot the steam used is

$$172.8 \times 0.139 \times 60 = 1440 \text{ lb.}$$

per hour. Assuming that 10 per cent. of the steam furnished is lost in condensation, leakage, etc., the amount of steam furnished is

$$1440 \div 0.90 = 1600 \text{ lb.}$$

per hour. The work done by the pump, as shown above, is 86,184,000 ft.lb. per hour, so the duty of the pump alone is

$$86{,}184{,}000 \div 1.6 = 53{,}865{,}000 \text{ ft.-lb.}$$

per 1000 lb. of steam.

As the duty of a pump similar to the one under consideration installed by the Boston water department was 60,727,400 ft.-lb. per 1000 lb. of steam under test, it is evident that the pump is not responsible for the low efficiency of this plant. The cause of its inefficient operation must therefore be an incorrect arrangement of the oil burners or an excessive steam consumption of the auxiliaries.

C. S. STOUFFER.

Kewanee, Ill.

The Critic Criticized

As one of a large number of people who have found Moyer's "Power Plant Testing" a valuable book, I feel compelled to protest mildly against the statements made in your review of Mar. 19.

Latterly, POWER has done much to improve its book reviews, and there is less reason for complaint against them than against those in many other technical papers, where they are often nothing more than a digest of the author's preface.

Prof. Moyer's book, it seems to me, is admirably adapted to the purpose for which it was written; namely, a college textbook, and, furthermore, it has been a very useful book to a lot of practicing engineers whom I know.

The reviewer was not only very sharp in his phraseology but somewhat inaccurate in his statements; he also gave no apparent consideration to the purpose of the book. Naturally, no one would expect, or even tolerate, very much absolutely original subject-matter in a book intended to cover concisely so large a subject. A far more just criticism would have been to say that the author was blowing his "horn" a little too hard for himself and his professional friends. Furthermore, the book certainly would not have been complete without the digest of the standard American methods for testing boilers, engines, turbines and pumps.

Unless the reviewer referred merely to "style" in the presentation of the subject-matter, I see nothing at all in his argument; and, as to matters of "style," we could argue till doomsday, and arrive nowhere.

If the work had "smacked of originality" or met in any way the reviewer's ideas as outlined in the first paragraph, it would utterly fail in its usefulness as a college textbook.

The reviewer is certainly mistaken also when he states in effect that the subjects "belong in the usual list found in books on experimental engineering." The writer is familiar with the books in English on this subject and he is quite sure that at least one-third of the subject-matter will not be found in any other book on "experimental engineering" published before the appearance of Moyer's "Power Plant Testing"; and, on the other hand, practically all of this matter is covered in about the same number of pages in all books published more recently on this general subject.

Criticisms regarding the illustrations also are, in some respects, unjust, as the writer can see that the publishers must have gone to very great expense to make new figures for many kinds of apparatus that are purely commercial, apparently to avoid the "stock" criticism of reviewers of technical books that "the figures are mostly from trade catalogs." It is true that some of the figures are conventional of textbooks; but in every case, apparently, proper credit has been given.

As to whether the reviewer has "seen many of the figures in government reports," I believe he is mistaken. The writer has, of course, observed figures illustrating such standard commercial apparatus as separating steam calorimeters and Atwood's and Junkers' fuel calorimeters in such reports; but those in Moyer's book, in my opinion, are about as much different as it was permissible

to make them and still illustrate correctly their commercial forms.

Does POWER deem it necessary to sacrifice accuracy of statements to make a review "breezy"?

POWER'S plans for book reviews are excellent. I am only "kicking" about what they should not be—about the kind that makes no attempt to find out what the author was trying to do, and then "roasts" a book for what it is not.

R. E. SMITH.

New York City.

Centrifugal Pump Troubles

I do not see that the distribution of the pumps in Milton Baker's pump problem, in the Mar. 26 issue, is at all necessary. The pipe line and pumps together form a closed conduit from the lower to the upper water levels; therefore the amount of head or pressure developed by each pump depends upon the speed and design of its propeller and not on its location in the line.

The three pumps should be placed together near the lower level to avoid further trouble. This would increase the pressure on the pipe just above the pumps, but would do no harm.

If it is not considered practicable to move the upper pumps, it might be possible to operate them without mishap if the following precautions are observed:

Place a bypass around each check valve except the one on the suction to the lower pump, and see that the column of water is solid before starting the pumps. Then start the tower pump first, adjusting it so that it will run at full speed as soon as the others start. It will probably not move any water with the full 70-ft. head against it, but it will develop sufficient pressure to hold the column of water together and start the flow when the other pumps start. Then start the middle pump in the same manner and lastly the upper pump.

When shutting down the order should be reversed, stopping the upper pump first. All this is based on the assumption that they are protected by speed governors. If they are run "by the throttle," the lower pump will be apt to develop a dangerous speed when the others are shut down.

By following this plan the only chance for trouble that I can see is in case one of the lower pumps stops running from some accident. If this should happen, the other pumps should be shut down at once and the columns of water brought safely together by opening the bypasses around the upper check valves.

Mr. Baker says they are contemplating placing air chambers at the discharge of the pumps. I would suggest that they call in an expert in this matter; the conditions warrant it.

FRED BOONE.

Davidson, Okla.

Mr. Baker's plan of placing air chambers at the discharge of the pumps to cut down the jar due to the making and breaking of the column of water in the line, will no doubt help conditions materially, but why not have a means of starting all the pumps simultaneously? He does not name the type of motive power for the pumps, but a satisfactory starting device could be arranged with either steam or electric drive.

R. G. COX.

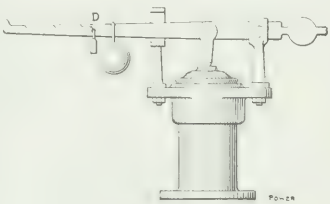
Milwaukee, Wis.

Valve Locking Devices

I quite agree with John Thorn as to his statement in the Mar. 12 issue of the importance of locking many valves.

At a plant where I was employed the native labor would persist in moving the weight on the lever of the air-compressor safety valve, causing no end of trouble.

To avoid all this I locked the weight as shown in the accompanying illustration. I bored a hole in the valve lever



A LOCKED SAFETY-VALVE

as shown at *D* and inserted a padlock in it. This prevented the weight being moved any appreciable distance. The job was completed in a short time and my mind put at ease, as the valve was located outside the building and consequently out of my sight.

B. W. BARRENO.

San Luis Potosi, Mex.

Central Station vs. Isolated Plant

V. S. Ball's article under the above heading in the Apr. 9 issue gives the other side of the question, but all will not agree with him.

Of course, there are plants running under conditions where the central station could give better service, but where there is a plant running 12 months a year and the central station can sell it power cheaper than the plant can make it, some fault is to be found either with the engineer or his employer.

In his example of a case where the central station could save a company money, Mr. Ball relates a case where a concern keeps an engineer running part of the plant until midnight to light an electric sign.

If the chief engineer of this plant was a "live one," he would have a storage battery to run that sign; he would save fuel and the engineer's wages.

There are very few employers, in my opinion, who will not listen to an engineer's suggestion for saving money if it sounds reasonable. Mr. Ball tells of another case where an engineer got a better job through letting the central station take his plant away from him. I do not think that a man who knows much about engineering will be content to let a central station get his plant.

Most "live" engineers work for something besides the pay envelope; most of them are looking for more experience and bigger plants, and I cannot see why a man could be contented just oiling shafting and running a heating boiler, as Mr. Ball said he would. It seems to me that a man who is satisfied with such conditions is either a starter and stopper or a has-been.

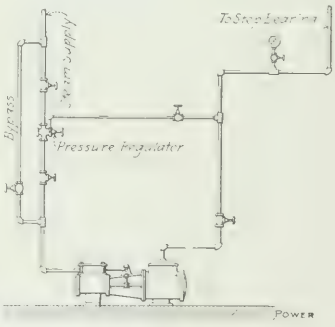
L. W. CHADWICK.

Bridgewater, Mass.

Oil Pipe Leaked

Luke Marier's letter of the Mar. 19 issue mentions that the oil pressure in the discharge line from the pump supplying the step bearing on the turbine varies with the boiler pressure, and that when the steam pressure drops the pump slows down, allowing the oil pressure to drop also, which, as he states, is dangerous practice for that type of turbine.

I believe if he will connect up his pump as shown in the accompanying sketch, he will overcome the trouble. It will be seen that a pressure regulator is used in the steam-supply line and connected to the pump-discharge line in the usual manner; also that the steam



PRESSURE PUMP AND PIPING

is bypassed around the regulator in such a manner as to permit repairs to be made, should they ever become necessary while the pump is in operation.

With this arrangement, should the steam pressure drop enough to slow down the pump and cause a drop in pressure in the oil line, the regulator would at once open up, allowing more steam to flow into the pump and maintain sufficient pump speed to hold the oil pres-

sure at the required point; then as the steam pressure increases again the oil pressure will also increase. The oil pressure will act on the regulator, thereby decreasing the amount of steam flowing to the pump and preventing the oil pressure from going higher than the determined point. A good regulator can be made to regulate very closely and maintain practically constant pressure under varying steam-pressure conditions.

THOMAS BAKER.

New York City.

Automatic vs. Fixed Cutoff for Compound Engines

In the Mar. 5 issue, William E. Francis has a letter relating to a pumping engine. He refers to the governor controlling the cutoff on the high-pressure cylinder, "while the cutoff for the low-pressure cylinder was regulated by hand."

This brings to mind some inquiries I made some time ago relating to automatic and fixed (hand-regulated) cutoffs for low-pressure cylinders of compound engines. The questions were these: "What is the idea of a fixed cutoff on the low-pressure cylinder of a compound engine? Under what conditions would it be desirable to use the fixed cutoff instead of that which is controlled by the governor?" Desiring to learn as much as possible concerning the matter, I wrote to several makers of compound engines for information, and it was courteously given.

One firm stated that the cutoff on all its compound engines is controlled by the governor. Fixed cutoff for the low-pressure cylinder was ordered for the purpose of throwing more load on the high-pressure cylinder when running light, thereby raising the receiver pressure. This would prevent the formation of a vacuum in the receiver and allow no water into the low-pressure cylinder.

Another company claims that a governor-controlled cutoff for both high- and low-pressure cylinders maintains a constant receiver pressure, the power in the cylinders being varied by the variable cutoff. This construction, it is claimed, is particularly adapted to 60-cycle electrical generation as "it reduces to a minimum the tendency to increase or decrease the engine from uniform rotation." This company uses the fixed cutoff on compound- and triple-expansion pumping engines.

Another concern claims that the fixed cutoff is less expensive to make and can be used advantageously on engines running under uniform load, such as pumps and air compressors.

One firm sees no advantage in a fixed cutoff, but claims that poor regulation results from its use. It infers that a fixed cutoff is dangerous on account of the possibility of excessive speeds being attained if the main belt should break or the circuit-breaker blow out.

CHARLES J. MASON.

Scranton, Penn.

A Pumping Problem

William Bettis' letter in the issue of Mar. 12 is very misleading in regard to the action of centrifugal pumps. He is correct in figuring that the water would rise to a height of 14 ft. when there was no flow, but when water is being delivered the result is very different and the pressure head developed may be far from $V^2 \div 2g$. In fact, it is well known that many centrifugal pumps will pump water to a height greater than they will raise it when there is no water flowing. For instance, the pump Mr. Bettis illustrates would probably deliver water to a height of 15 ft. if it once got started. This would be impossible if his statement that "14 ft. would then be the total head that the pump was capable of at the given speed" was true. He should apply Bernoulli's

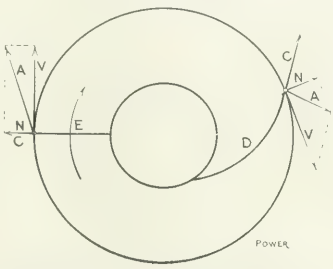


DIAGRAM TO ILLUSTRATE BERNOUILLI'S THEOREM

theorem for flow though a rotating casing instead of the theorem for flow through stationary pipes.

The accompanying illustration shows more nearly what actually is taking place. This represents the runner of a centrifugal pump; D is a vane having a backward rake and E is a radial vane. Let V represent the velocity of the tip of the impeller, C the velocity of the water relative to the impeller and N the normal component of the velocity of the water as it leaves the impeller. Then A will be the real or absolute velocity of the water as it leaves the impeller. When the vanes are radial, N and C coincide.

When no water is flowing, C is zero and A is equal to V and the pressure head is equal to $V^2 \div 2g$ as Mr. Bettis figures. But the water also has a velocity head equal to $V^2 \div 2g$, making the total head at the tip of the impeller equal to $V^2 \div g$, or twice the maximum head that Mr. Bettis figured. Since he figured the velocity head at the end of the pipe, he should not neglect the velocity head at the tip of the impeller.

When water is flowing, the pressure head at the tip of the impeller, according to Bernoulli's theorem, is $(V^2 - C^2) \div 2g$. In other words, the runner still develops a pressure head of $V^2 \div 2g$, but $C^2 \div 2g$ is used to give the water the relative velocity C; this leaves $(V^2 - C^2) \div 2g$ as the pressure head at the tip of the impeller. Since C is larger with vanes like D than with those like E, radial vanes give a higher pressure than curved vanes when the speed and volume pumped are the same. In addition to the pressure head at the tip of the impeller, the water has a velocity head of $A^2 \div 2g$. This velocity head can be converted into pressure by stopping the water without shock. Therefore the total head at the tip of the impeller is $(V^2 + A^2 - C^2) \div 2g$; $(V^2 - C^2) \div 2g$ equals the pressure head and $A^2 \div 2g$ equals the velocity head. With radial vaned pumps $(A^2 - C^2)$ is equal to V^2 and $(V^2 + A^2 - C^2) \div 2g$ is equal to $V^2 \div g$. With vanes having a backward rake $(V^2 + A^2 - C^2) \div g$ is less than V^2 and with vanes having a forward rake $(V^2 + A^2 - C^2)$ is greater than V^2.

In order to prevent shock, it is necessary to reduce the velocity A gradually, and this is the purpose of the volute and of the guide vanes in the diffuser of turbine pumps. It is evident that $A^2 \div 2g$ is greater with radial vanes than with curved vanes with the same speed and rate of flow; consequently the loss with D is less if the volute or diffuser is poorly designed. When centrifugal pumps were first made they had radial vanes, but Appold found that vanes like D gave much higher efficiencies. This was because the pumps had no diffusers and poorly designed volutes; hence $A^2 \div 2g$ was lost. By careful design, pumps can now be made with radial vanes that give as high efficiencies as those with curved vanes.

From the figure it is also evident why a pump with radial vanes would overload worse than one having curved vanes. The volume pumped is proportional to N, while the pressure at the tip of the impeller is $(V^2 - C^2) \div 2g$. Now with curved vanes, if N increases, C increases much more and $(V^2 - C^2)$, the pressure, takes a heavy drop. With radial vanes, if N increases, C is increased by the same amount and the drop in pressure is not so great as with curved vanes; in other words, a given drop in head causes a much larger increase in volume with radial vanes than with curved vanes.

In this discussion, losses by friction and shock are neglected and the velocity of the water, at the entrance to the pump, is assumed to be zero.

GEORGE L. SULLIVAN.

Bozeman, Mont.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Lead Required for a Slide Valve Engine

What lead is required for a 5x7-in. slide-valve engine?

D. J.

It is customary to set the valve so that a knife blade can be inserted between the edge of the valve and that of the port, when the engine is on dead center. All that is necessary is to admit steam quickly, so that the admission line of the diagram will not incline inward.

Longitudinal Seams

Why are the longitudinal seams of a boiler made double or stronger than the circumferential seams?

B. H.

The force tending to pull a boiler apart endwise is the pressure acting upon the area of the head. The metal resisting this is the product of the circumference and the thickness. The force tending to burst a ring 1 in. long is the product of the pressure per square inch and the diameter, and the area of the metal resisting it is, since the length is unity, the product of the thickness by 2. The force on each inch of circumferential seam is proportional to

$$\frac{Pressure \times diam. \times 3.1416}{4} = \frac{Thickness\ of\ sheet \times diam. \times 3.1416}{pressure \times diam.}$$
$$4 \times thickness$$

and the stress on each inch in length of the boiler is proportional to

$$\frac{Pressure \times diam.}{2 \times thickness}$$

It is plain that, whatever the diameter, the stress on the longitudinal seams per unit of section will be twice that on the circumferential seams.

Range of Cutoff of Corliss Engines

Will the valves remain hooked and the steam follow full stroke, in a double-eccentric long-range cutoff Corliss engine when the engine is running slow?

R. C.

In any Corliss engine running below speed, if the safety cams do not prevent the valves from hooking on, the steam valves will remain open the entire stroke or until shut off by the lap, providing the speed is reduced to such an extent that the detaching mechanism does not release.

On either a single- or double-eccentric engine the cutoff cannot happen after the eccentric passes the center. On a double-eccentric engine the angular advance is less so the eccentric will not pass so early in the stroke.

Slide Valves and Diagrams

Suppose a slide valve cuts off at three-quarters stroke and a five-eighths cutoff is desired, what is the procedure? How is the proper length of an indicator diagram determined for any stroke and how is the proper bushing for the reducing wheel to be found?

F. W.

Advance the eccentric; this will also cause the engine to take steam earlier and release the exhaust and close it earlier. To preserve the same lead, add lap to the valve.

No particular length of diagram is imperative, but for purposes of analysis and measurement it is generally desirable to obtain the longest diagram consistent with good operation of the indicator. Diagrams from high-speed engines—i.e., making 200 r.p.m. and upward—are usually taken only 2 to 3 in. long, so as to reduce the error due to the inertia of the indicator paper drum. For slower speeds, most patterns of indicators are adapted for taking diagrams 1½x3 in.

Manufacturers of reducing wheels usually stamp figures on the edge of each shell or bushing to signify the length of the engine stroke for which the bushing is suitable. Of course, a bushing may be used with any shorter stroke of engine, provided the length of the diagram is satisfactory to the operator. The best manner of finding the proper size of bushing is to hitch up the reducing motion to the indicator with any medium-size bushing, and with a blank card on the paper drum and pencil lightly pressed against the card, draw out the main indicator cord by hand, until the pencil has marked off a line whose length is equal to the desired length of the diagram. In order to find the size of the bushing required for the same length of diagram for any stroke of engine, multiply the outside diameter of the trial bushing in inches by the length of the cord in inches which had to be drawn out by hand, and divide by the stroke of the engine in inches. The quotient will be the outside diameter of the bushing required to produce the length of diagram desired. As the length of the diagram need not be exact, the diameter of the bushing need be only approximately the size estimated, but it is always desirable to obtain the travel of the paper drum that will produce a diagram about 1 in. shorter than the maximum travel of the drum, so as to leave a margin for adjusting the length of the cord.

Effect of Increased Circumference

Assuming the earth to be 25,000 miles in circumference and to be surrounded by a tight-fitting steel band, how far from the earth would the band be, if the band were cut and 30 ft. inserted?

A. F. F.

The increase in the diameter would be 30 divided by 3.14159, regardless of the original diameter. The original diameter is

$$\frac{Circumference}{3.145159}$$

and the new diameter

$$\frac{Circumference + 30}{3.14159}$$

Therefore, the difference will be

$$\frac{30}{3.14159} = 9.55\ ft.$$

whatever the original diameter. The band will be raised above the earth half this distance, or 4.77 ft.

Equalizing the Work Done by a Cross-Compound Engine

How can the work done by the high- and low-pressure cylinders of a cross-compound engine be adjusted?

A. D. J.

By changing the cutoff in the low-pressure cylinder. The earlier the low-pressure cutoff the higher will be the receiver pressure, i.e., the greater will be the back pressure in the high-pressure cylinder and the initial pressure in the low-pressure cylinder, which will have the effect of reducing the work done in the high-pressure cylinder and increasing that done in the low-pressure cylinder.

The Bristol Recording Water Level Gage

The Bristol Co., of Waterbury, Conn., has recently put upon the market a gage for indicating and recording the depth of liquid in a tank or stream. A bronze casing provided with a very flexible diaphragm or membrane free from tension due to the elasticity of the rubber from which it is made, is submerged in the liquid, the depth of which is to be measured as shown in Fig. 1. The space above the diaphragm is air- and watertight and the pressure of the air confined in it is directly proportional to the head of liquid acting upon the under side of the diaphragm. It remains only to convey this pressure to a recording gage

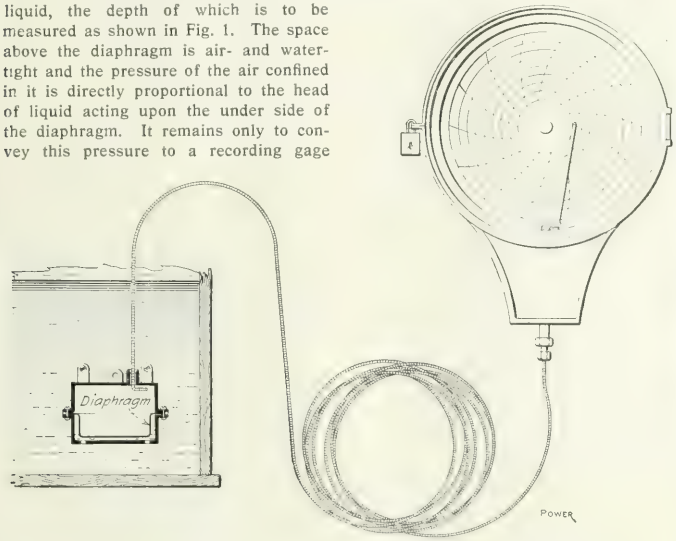


FIG. 1. SENSITIVE BULB CONNECTED TO A RECORDING INSTRUMENT

of sufficient sensitiveness to accomplish the object sought.

The instrument is so set that when the liquid is at the minimum level the pressure tube of the recording instrument is subject on the inside and outside to atmospheric pressure only. The indication is not affected by the relative

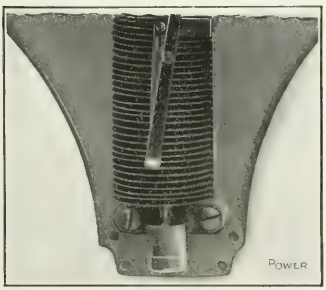


FIG. 2. FLEXIBLE DIAPHRAGM OF RECORDING INSTRUMENT

level of the gage and the liquid, so that the gage may be placed above as well as below the tank and at any reasonable distance. By applying the gage to the measurement of the depth of liquid flowing over the sill of a weir or through an orifice, the quantity of water flowing may be determined and the gage calibrated to read in these quantities.

As no float is used and the exposed portion of the apparatus is submerged, it is not subject to derangement by floating ice and is independent of temperature, for the pressure is transmitted by a column of air and there is nothing to freeze. In cases where conditions require, as in a rapidly flowing stream, where it might be interfered with by the flow, the submerged casting may be protected by placing it inside a perforated case or barrel.

The variation in pressure with water is only about ½ oz. for each inch in head. To record this slight difference upon the large scale the same delicate

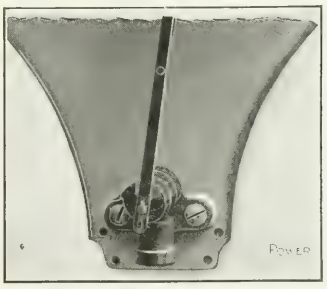


FIG. 3. SPIRAL TUBE OF RECORDING INSTRUMENT

apparatus is used which enables the aneroid barometer to indicate the difference in atmospheric pressure between the table and the floor level. This consists of a series of very flexible diaphragms shown in Fig. 2. Each of the several diaphragms is inflated and the aggregate movement of the series is available for transmission to the recording arm. This form of pressure tube is usually employed for ranges under 12 ft. and the record may be had upon any scale which will allow the total variation to come within the range of the chart. For higher ranges where a greater actuating force

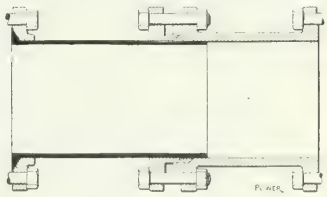
FIG. 4. MOISTURE PROOF CASING

is available, a spiral tube, Fig. 3, is used.

If a recording instrument is to be installed in an exposed position, the moisture-proof case, shown in Fig. 4, is available, while for inside use the ordinary form, shown in Fig. 1, will naturally be used.

P-K Expansion Joint

In this expansion joint the sleeve flange is made of cast iron and faces against the beveled surface of a boss cast on the end of a brass sleeve. The shell in which the sleeve fits is made of cast iron. Triple metallic packing, consisting of three triangular sections, the composition being



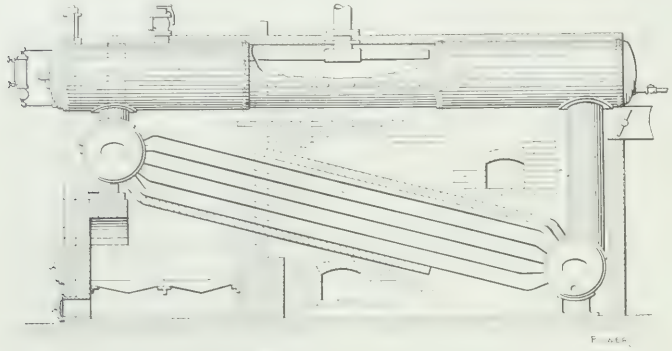
P. K. EXPANSION JOINT

determined by the pressure and temperature under which it works, is used when the joint is for steam. Rings of special hydraulic packing, composed of rubber and heavy duck, are used for water service.

This joint is manufactured by the P-K Engineer, 1309 Syndicate Trust Building, Tenth and Olive Sts., St. Louis, Mo.

Cylindrical Header Boiler

The boiler shown in the accompanying figure has been designed for use where headroom is limited. It is built in units up to 150 hp., with five rows of 3½-in. tubes expanded into cylindrical headers, front and rear. These headers are connected to a steam and water drum of suitable proportions, as shown.



Boiler with Cylindrical Headers

Boilers of larger size are designed with two or more sections, one above the other, each five tubes high. No stayed surfaces are used in any part of the boiler and all parts are cylindrical.

This boiler is manufactured by the Carr Boiler Co., Monadnock Block, Chicago, Ill.

National Direct Contact Heater and Purifier

The back head of this heater consists of an oil separator of the same diameter as the shell. A manifold, cast on the front head, serves as a distributing chamber to the double cast-iron contact pipe, shown in Fig. 1, which is closed at the outlet ends. The inner water pipe is connected to the water manifold on the front head, through which the water is discharged. The outer or steam pipe is connected to the outlet of the steam separator on the back head.

The water pipe has a port opening its entire length on the upper side, to the outside of the steam pipe, which has a port extending its full length at the bottom. Water entering the water pipe flows upward through the port, and passes in a thin film over the outside surface of the steam pipe until it reaches a rib projecting from each side of the port opening at the bottom, where it is broken up into fine spray.

The only outlet for the steam in the steam pipe is through the port in the bottom. The cold-water pipe on the inside of the steam pipe is surrounded by steam, and the coldest water is heated by the hottest steam through contact with the thin wall of the water pipe. The water is further heated as it passes over the outer surface of the steam pipe, and finally all of the water and all of the steam are brought into direct contact as the steam flows through the bottom port.

The hot water and condensed exhaust are carried by pans direct to the sediment chamber at the bottom of the heater, where the solid and heavy impurities settle. The water then passes upward through a filter bed which removes the remaining impurities. Connection between the feed-water pump and the hot-water chamber is made above the filter bed. The filter is so designed that in case it should become clogged, heated water can be bypassed and fed direct to the pump.

Fig. 2 shows the oil separator. The large area allows the incoming steam to expand and reduce its velocity to a point where oil or water will fall out of the current by gravity. These particles impinge on the main baffle-plate, which is provided with vertical ribs to prevent side travel of water or oil. A series of tube ports are fitted in the baffle-plate. The steam makes a right-angle change in direction upon striking the baffle-plate and the projecting tubes cause a further change in its direction of flow. These reversals of travel prevent oil from being carried beyond the main baffle-plate.

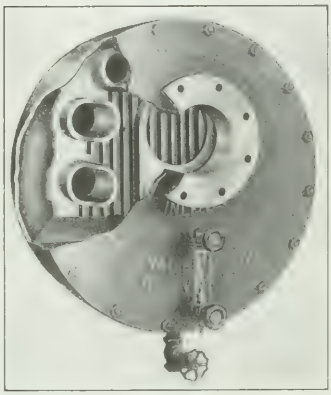


Fig. 2. Oil Separator

This heater is manufactured by The National Pipe Bending Co., New Haven, Conn.

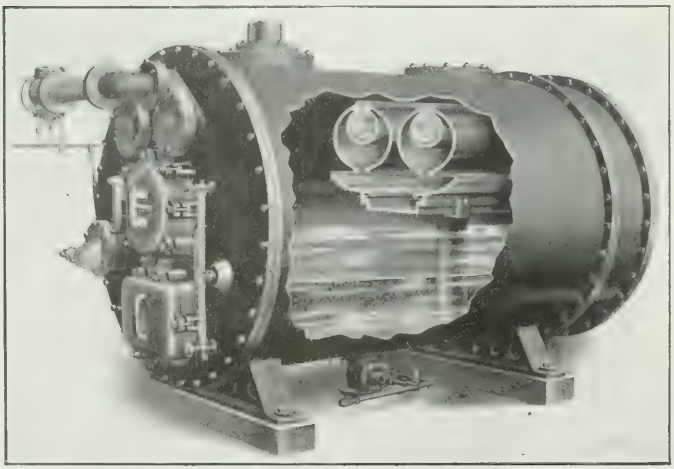


Fig. 1. Showing the Heating Tubes of the Heater

The story is told that a letter received some years ago by the Westinghouse Machine Co. said that the writer had been using one of its standard vertical engines with eminent satisfaction. For eight years it had been in continuous service night and day, handling its load without a hint of trouble, but that "upon shutting it down the other evening it went all to pieces." The letter was passed to the eminent inventor whose name the company bears, and handed back with the remark: "Ask the blamed fool what he shut it down for."

Study Questions

The answers to these questions will appear in the issue of May 21:

1. An engine having 5 per cent. clearance, cutting-off at quarter stroke, with 85 lb. initial pressure (gage) and exhausting at 15 lb. absolute, has an m.e.p. of 44.6 lb. What would be the "diagram factor"; i.e., what percentage of the ideal diagram would be covered by the actual diagram, the product of the volume and pressure being assumed to remain constant during expansion?

2. If one man can do a piece of work in eight days, another in 12 days and another in 10 days, how many days will it take all three to do the work if all trhee work together?

3. An engine taking steam at 120 lb. absolute, containing 2 per cent. of moisture, requires 16 lb. per horsepower-hour running condensing. If the cooling water in the condenser has an initial temperature of 60 deg. F. and a final temperature of 100 deg. F., how many pounds of water will be required to condense 1 lb. of steam exhausted by the engine, neglecting radiation?

4. What pressure would be necessary to deliver 200 gal. of water per minute through a horizontal 4-in. pipe line 400 ft. long, the water discharging into an open tank?

5. The volume of a spherical segment is 29.3216 cu.ft., the diameter of the sphere is 6 ft.; required, the height of the segment and the length of its base.

Truro (N. S.) Plant Wrecked

On May 2, the power plant of the Chambers Electric Light & Power Co., at Truro, N. S., was badly wrecked by the explosion of a flywheel, While there were no lives lost, it is said that the monetary loss was large.

According to the press reports, the flywheel burst at 7:15 a.m., the flying pieces destroying the dynamo and wrecking the power-house interior. One piece, weighing 172 lb., was blown through the roof, landing in front of St. Andrew's church, 270 yd. distant. Another, weighing as much, was blown through the big brick wall and forced its way through the second brick wall of an adjoining furniture store, and a big fragment tore through the power-house wall and then through the wall of the laundry adjoining.

The president of the company was just about to enter the door of the power house and the concussion hurled him many yards away, unhurt. An employee dashed into the building amid falling bricks and plaster and débris and shut off the steam.

As the company has duplicate emergency engines and dynamos, the light and power service was not interrupted.

Boiler Explodes in Saw Mill

On Friday, Apr. 19, a boiler exploded at Combs, Tenn., killing the fireman and injuring two other employees.

According to our correspondent, the boiler was 36 in. by 12 ft. and connected to a larger boiler with no stop valve in between, and only one safety valve for both. The lever of the safety valve was not notched and a large screw jack was used as a weight which would slip to the end of the lever while the boiler was in operation, the weight being moved back every morning before starting the fires.

The boiler had several patches on it and had not been in service for about three years until a week previous to the explosion; its plates were ¼ in. thick, but many of them were so badly corroded that they were reduced to ⅛ in. Although 90 lb. was the usual pressure, 140 lb. was carried at the time of the explosion. The boiler was not insured and therefore never inspected by an official inspector.

Examination of the plates showed that while no rivets were sheared the plates were torn in many pieces. The larger boiler was thrown about 30 ft. from its settings, and the sheets were considerably sprung and distorted. Our correspondent said he was advised that "She was all right, however, and another second-hand boiler would be installed in place of the exploded one."

The A B C of Boiler Room Chemistry

Under the auspices of the Institute of Operating Engineers, an interesting and instructive lecture on the essentials of boiler-room chemistry was delivered by H. J. Atticks, a member of the institute, in the Engineering Societies Building, at 29 West Thirty-ninth St., on the evening of Apr. 25.

The speaker stated that the purpose of the talk was not to go into the complexities of chemistry, but rather to give a comprehensive idea of the fundamentals of the science and its relation to power-plant practice.

He told of the indestructibility of matter and defined the meaning of an element; "compounding of the elements and the study of compounds" was the chief purpose of chemistry. The symbols of the chemicals met with in power-plant practice were also clearly explained, as well as the meaning of qualitative and quantitative analyses, atomic weight and chemical affinity.

Mr. Atticks then took up the analysis of boiler waters, illustrating his talk by actual tests of water containing carbonate of lime and sulphate of lime. These samples were heated in test tubes to ascertain the amount of precipitation, and tubes were then passed through the audience for inspection. The action of dangerous corrosive agents in water, such as chloride of magnesium and sulphuric acid, were well explained.

Heat and the combustion of coal were next taken up and were followed by an actual analysis of the flue gases with the Orsat apparatus. This part of the lecture was particularly instructive as the functions, construction and manipulation of the apparatus were given in detail. It was explained that the pipettes of the apparatus contained potassium hydrate for determining the percentage of carbon dioxide, solution of potassium pyrogallate for determining the percentage of oxygen and cuprous chloride for determining the percentage of carbon monoxide respectively, and that the analyses should be taken in the order given. The readings of the apparatus were made plainly visible by placing a strong light back of the Orsat.

The lecture was a success both in attendance and in the practical manner in which the speaker handled his subject.

Diesel Engines for America

The *London Times* states that on the recommendation of a commission of American engineers sent especially to Europe to visit the leading firms of Diesel-engine makers in England and on the Continent, an English firm has made arrangements whereby the General Electric Co. will build Diesel engines to their design.

The A. S. M. E. Convention

The date for the spring meeting of the American Society of Mechanical Engineers has been changed to the last week of May, opening on Tuesday, May 28, and closing on Friday, May 31. Every effort is being put forth by the committee on meetings and the members in Cleveland to make this one of the great conventions of the society, and the variety and importance of the city's industrial works and its attractiveness as a whole will make it one of the most interesting cities in the country for a meeting of engineers.

A tentative program of the papers and entertainment, subject, however, to change, follows. The professional sessions will be held in the Hall of the Chamber of Commerce.

TENTATIVE PROGRAM

TUESDAY, MAY 28

Opening of registration at headquarters, Chamber of Commerce Hall, after 10 a.m.

Informal reception, 4 to 6 p.m., at the home of Mr. and Mrs. Ambrose Swasey, 7808 Euclid Ave.

Membership reunion and informal reception, at 8:30 p.m., at the Chamber of Commerce Hall.

WEDNESDAY, MAY 29

Business meeting, 10 a.m.; reports of tellers of election and committees, and new business.

Professional session, 10:30 a.m. Papers: "A New Analysis of the Cylinder Performance of Reciprocating Engines," J. Paul Clayton; "Equipment of a Modern Flour Mill on a Gradual Reduction System," John F. Harrison and W. W. Nichols; "Design and Mechanical Features of the California Gold Dredge," Robert E. Cranston. To be read by title only; discussion is invited.

Gas-power section, 10:30 a.m.; simultaneous session in Chamber of Commerce library. Paper: "Problems in Natural Gas Engineering," Thomas R. Weymouth. Other papers to be announced.

Special inspection trip for ladies, at 10 a.m., to the plant of the H. Black Co., cloak manufacturers.

Members and guests will be entertained at luncheon at 12:30 p.m. in the Chamber of Commerce Hall.

Excursions at 2 to 4 p.m.: Inspection by members of local manufacturing and power plants; automobile trip for ladies through the parks; tea will be served at the Country Club at 4 p.m., to which members and guests are invited.

Lecture, 8:30 p.m.: "Sound Waves: How to Photograph Them and What They Mean," Dr. Dayton C. Miller, of the Case School of Applied Science. The lecture will be illustrated with apparatus and experiments and especially with the new instrument, the "Phonodeik," for projecting sound waves directly upon the screen.

THURSDAY, MAY 30

Professional session, 10 a.m. Papers: "New Processes for Chilling Cast Iron," Thomas D. West; "Strength of Steel Tubes, Pipes and Cylinders under Internal Fluid Pressure," Reid T. Stewart; "On the Control of Surges in Water Conduits," W. F. Durand; "Speed Regulation in Hydro-electric Plants," William F. Uhl. To be read by title only; discussion is invited.

Thursday afternoon, at 1 to 5 p.m., there will be an excursion on Lake Erie, and in the evening, at 8:30 p.m., a reception and dance at the Colonial Club.

FRIDAY, MAY 31

Professional session, 10 a.m. Papers: "The Present State of Development of Large Steam Turbines," A. G. Christie; "A Discussion of Certain Thermal Properties of Steam," G. A. Goodenough; "The Reduction in Temperature of Condensing Water Reservoirs Due to Cooling Effect of Air and Evaporation," W. B. Ruggles; "Results of Tests on the Discharge Capacity of Safety Valves," E. F. Miller and A. B. Carhart. To be read by title only; discussion is invited.

The members and guests will be entertained at luncheon at the Chamber of Commerce Hall promptly at 12 o'clock.

An inspection of the plants of the Goodrich Rubber Co., the Wellman-Seaver-Morgan Co., at Akron, and the Diamond Match Co., at Barberton, will be made at 12:30 p.m.; the ladies are invited to make the trip to Akron.

The plans for the entertainment and reception of members and their guests are in charge of the local members in Cleveland. The executive committee, composed of the chairmen of the various sub-committees, is as follows: Ambrose Swasey, chairman; R. H. Fernald, vice-chairman; R. B. Sheridan; treasurer, F. W. Ballard, secretary; S. T. Wellman, E. P. Roberts, Worcester R. Warner, G. E. Merryweather, A. G. McKee.

N. A. S. E. State Conventions

The following gives the places and dates of the annual state conventions soon to be held by the associations of the National Association of Stationary Engineers:

California, Santa Barbara	May 23-26
Colorado Idaho Springs	June 7-8
Connecticut, Bridgeport	June 28-29
Illinois, Decatur	May 23-25
Indiana, Evansville	June 6-8
Iowa, Sioux City	June 27-29
Kentucky, Owensboro	
Massachusetts, Northampton	July 11-13
Michigan, Flint	Aug 1-3
Minnesota, Winona	July 17-20
Missouri, Joplin	June 20-22
New Jersey, Newark,	May 30, 31, June 1, 2
New York, Yonkers	June 14-16
Ohio, Lima	June 20-22
Pennsylvania, DuBois	June 7-8
West Virginia, Clarksburg	
Wisconsin, Racine	July 24-27

Pittsburg Meeting of the Ohio Society

The Ohio Society of Mechanical, Electrical and Steam Engineers is determined to set a new high record for its coming meeting at Pittsburg on May 16, 17 and 18.

A special effort is being made by the Pittsburg committee to make the entertainment program of sufficient interest to induce a large attendance of the members' ladies. During the trip to the testing station, Bureau of Mines, and the laboratories of the Geological Survey, the ladies will be entertained at the Arsenal playgrounds, near-by.

The opening session, on Thursday evening, will be at the rooms of the Engineers' Society of Western Pennsylvania, Oliver Building. An "owl" party for the men will be organized immediately after the opening session at Engineers' Hall. It will visit the Phipps power plant at 11 p.m. and inspect the powdered coal stoking equipment, the largest installation of this type in the world. The inspection will last until 12 o'clock, when the party will adjourn to the Pittsburg Natatorium for a midnight swimming party.

On Friday an automobile tour of the residence district has been arranged for the ladies, starting at 10 a.m. from Hotel Schenley. The trip will conclude at 12:30 at the Margaret Morrison Carnegie School for Women, where luncheon will be served, followed by an inspection trip through the schools.

At the close of the Friday morning session the men will lunch with the students of Carnegie Technical Schools, and tour the engineering and mechanical department and testing laboratories, concluding in time to join the ladies and attend the ball game at Forbes Field at 3:30 p.m., as guests of the Pittsburg committee.

At 6 p.m. Friday, a complimentary dinner will be tendered the members and their ladies at the Hotel Schenley.

The committee has arranged for preferential trips to the Westinghouse works, the Jones & Laughlin Steel Co., and other Pittsburg plants for Friday afternoon or Saturday morning, for those members who are willing to skip a part of the regular program.

Convention of the A. O. S. E.

The twenty-sixth annual convention of the American Order of Steam Engineers will be held at Allentown, Penn., during the week beginning June 3. The mechanical exhibit will be located at the Fair Grounds, and in a spacious hall, adjoining the display, the business sessions of the delegates will be held.

Arrangements have been made for the accommodation of over 100 exhibitors, and many of the booths have already been taken.

An excellent program of entertainment has been prepared, and the general outlook seems to warrant a most successful convention.

Master Boilermakers' Convention

The sixth annual convention of the Master Boilermakers' Association will be held in Pittsburg from May 14 to 17. The headquarters will be in the large English room of the Fort Pitt Hotel. The local committee are J. B. Smith, chairman; Daniel S. Rise and Charles J. Reynolds.

Mayor William A. Magee will make the address of welcome, and other addresses will be given by D. F. Crawford, of the Pennsylvania R.R.; L. H. Turner, of the Pittsburgh & Lake Erie R.R.; William McConway, of the McConway & Torley Co., Pittsburg; M. O'Connor,

William H. Laughbridge, T. W. Lowe, George Wagstaff and George W. Bennett, the president of the association.

The women's auxiliary will also hold its annual convention in the Fort Pitt Hotel at the same time. It is said that smoke prevention will be one of the most important topics under discussion.

N. E. L. A. Seattle Convention

Among the papers and reports to be read at the Seattle convention of the National Electric Light Association on June 11 to 13, are "The Desirability as a Central-station Load of Pumping for Municipally Owned Water Works," Charles A. Munroe; "Educating Central-station Employees," H. E. Grant; "Twenty-four-Hour Service in Small Central Stations," Taliaferro Milton; "Work and Publications of the U. S. Government Relating to Hydro-electric Development," J. S. Hoyt; reports on power transmission; "A Plan for Increasing Power Load," H. W. Cope; reports of committees on prime movers and electrical apparatus; "Care and Operation of Transformers," W. M. McConahey.

Several of these papers will be abstracted in early issues of POWER.

Eighth International Congress of Applied Chemistry

The Eighth International Congress of Applied Chemistry will be held in Washington and New York, on Sept. 4 to Sept. 13, under the patronage of President Taft. The honorable president of the congress is Prof. Edward W. Morley, Sc.D., Ph.D., LL.D.; the president, W. H. Nichols, Sc.D., LL.D., and the secretary, Dr. Bernhard C. Hesse, 25 Broad St., New York City.

A preliminary pamphlet may be obtained from the honorable secretary of the British organizing committee, Charles G. Cresswell, Society of Chemical Industry, Palace Chambers, Westminster, London, S.W.

Special Meeting of N. A. S. E., Detroit

The Detroit branch, N. A. S. E., gave a reception to National President E. J. Kearny, of Boston, on May 6, and he was shown many courtesies during the day. At 8:30 p.m., in Association Hall, Ray Silver, president of Council No. 7, introduced Mr. Kearny, who in his address urged the members to keep in touch with progressive methods of operating engineering and told of the necessity for a state license law. He advocated the appointment of a civil-service board of examiners which would pass upon the fitness of engineers and boiler inspectors, and spoke of the advantages of state lectures on engineering.

Among the other speakers were State President Fuller, of Kalamazoo; Past National and State Presidents E. J. Jacques and Pearce; Vice-president Cressey, of Council No. 1, and Charles Ellis, president of the United Engineers.

Sixth Congress of International Association for Testing Materials

The organizing committee under whose auspices the sixth International Congress for Testing Materials will be held on Sept. 2 to 7 at the Engineering Societies Building, New York City, announces an informal reception on Monday evening, Sept. 2, under the joint auspices of the American Society for Testing Materials, the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers.

The congress will convene at 10 o'clock a.m., Sept. 3, with an address of welcome by Dr. Henry M. Howe, acting president, and by national, state and city officials. Over 150 reports and papers are in hand or promised, including 35 American papers.

A list of the delegates already appointed, together with the titles of the foreign papers to be read, are included in bulletin No. 2 issued in April by the organizing committee, in which is also given the itinerary of the excursions to points of interest in neighboring cities. The bulletin may be had on application to H. F. J. Porter, secretary of the committee, 1 Madison Ave., New York City.

SOCIETY NOTE

The twelfth annual six-weeks summer school of the College of Engineering, University of Wisconsin, will open on June 24. Courses of instruction and laboratory practice are offered in electrical, hydraulic, steam and gas engineering, mechanical drawing, applied mechanics, testing of materials, machine design, shopwork and surveying, in addition to which subjects may be taken in the College of Letters and Science. Address F. E. Turneaure, University of Wisconsin, Madison, Wis., for further particulars.

BOOKS RECEIVED

STEAM TURBINE DESIGN. By John Morrow. Longmans, Green & Co., New York. Cloth; 471 pages, 5¾x9 in.; 150 illustrations; plates; tables. Price, $4.50.

THE STEAM TURBINE. By Robert M. Neilson. Longmans, Green & Co., New York. Fourth edition; cloth; 651 pages, 5¾x9 in.; 415 illustrations; plates. Price, $5.

CENTRIFUGAL PUMPING MACHINERY. By Carl G. de Laval. McGraw-Hill Book Co., New York. Cloth; 184 pages, 6x9 in.; 160 illustrations; tables. Price, $3.

HOUSE WIRING. By Thomas W. Poppe. The Norman W. Henley Publishing Co., New York. Flexible cloth; 125 pages, 4½x6½ in.; 74 illustrations. Price, 50c.

KNOTS, SPLICES AND ROPE-WORK. By Hyatt Verrill. The Norman W. Henley Publishing Co., New York. Cloth; 128 pages, 4½x6½ in.; 148 illustrations. Price, 60c.

ELEMENTARY INTERNAL COMBUSTION ENGINES. By J. W. Kershaw. Longmans, Green & Co., New York. Cloth; 174 pages, 5x7½ in.; 117 illustrations. Price, 90c.

OBITUARY

SPENCER NEEMES

Spencer Neemes, of the Neemes Brothers, Troy, N. Y., died suddenly at his home, 150 Pawling Ave., Troy, N. Y., on May 5.

Mr. Neemes was born in Whitehaven, England, May 6, 1856, and came to this country with his parents a year later. The family located in Albany, where Mr. Neemes was educated in the public schools. He moved to Troy 38 years ago and with his father and his brother Joseph established the foundry business now carried on under the name of Neemes Bros. He was noted for his mechanical skill and inventive capacity, a genial companion and a public-spirited citizen, a well known Mason, a member of the Troy Chamber of Commerce and devoted much of his time and money to unostentatious charity.

Spencer Neemes is survived by his wife, formerly Cornelia M. Cornelius, a daughter, Grace, a son, Oscar G., his grandson, Spencer G. Neemes, and his brother Joseph. The interment was at Oakwood on May 7 with the Knights Templar service.

PERSONAL

Mark A. Replogle has been appointed district agent for the Northern Mississippi River and Lake State sections by the Lombard Governor Co., with offices in the Fisher Building, Chicago. Mr. Replogle is well known in waterwheel governor circles and formerly had charge of sales in the New England and St. Lawrence River sections.

Lawrence Paddock, formerly of the engineering department of the Prudential Insurance Co., of Newark, N. J., has taken charge of the plant of the Rosenbaum Jewelry Co., of that city. Mr. Paddock will be remembered as the engineer whose coolheadedness resulted in saving a number of employees at the Nathaniel Glass Co.'s fire in High St., Newark, on Nov. 26, 1910.

Earnest T. Child, George M. Scott and John E. Jeffery, with the name Child & Scott Co., have succeeded the corporation of G. A. Suter & Co., 108 to 114 Wooster St., New York City, engineers and contractors for heating and ventilating apparatus. The members of the new firm have been associated with Mr. Suter for many years and will continue in the same line of engineering.

Moments with the Ad. Editor

Many of you who read this page will be surprised to know that thousands and thousands of dollars have been spent in the past few years by manufacturers of machinery and allied lines in what are termed "general magazines."

That is to say, they have advertised to everybody in the hope of hitting somebody.

This would be fine business if they had only to *pay* for what they *hit*.

General magazines must of necessity aim to interest the universe from the world of politics to the world of fashion.

Hence their circulations are tremendous, and their readers as varied in pursuits, aims and occupations as the crowd that watches a circus parade.

Their advertising rates are based, as are those of all papers, upon the *quantity* of circulation. The advertiser pays for *everything*—and gets an infinitesimal portion of the lot as prospective customers.

The price per page, one time, for general magazines runs from $100 to $4000.

Now, here are some census figures that will show you, who are interested from the *reader's* point of view, how little chance a *general* advertiser, making, say, clothing, has in a *general* magazine.

Then you can figure how little chance a *machinery* advertiser has in general papers.

All men wear clothes—only a slight proportion of them buy machinery.

Assume that this clothing maker's product sells for an average of $30 per suit.

Fifty-two per cent. of the people live in the country; 10⅔ per cent. in semi-urban and 37⅓ per cent. live in cities and towns.

An average family consists of five persons.

Nearly 33 *per cent.* of these families have an average income of less than $400 per year or about $80 per capita.

Not many $30 suits to be sold there.

About 21 per cent. of these families have an annual income of $400 to $600.

Some 15 per cent. have an annual income of $600 to $900.

Only 10½ per cent. of them have an annual income of $900 to $1200.

Only 7½% of them have an annual income of $1800 to $3000. An average per member of the family of $360 to $600. (Now you're in the thirty-dollar-suit class.)

And only 5 per cent. have over $3000. (They are out of the "ready-made" class into made-to-order clothing.)

Some problem to advertise profitably, isn't it?

If your article is for men only or women only, your public is halved.

There are 9,000,000 negroes—10 per cent. of the population is black.

If your general magazine is a low priced one catering to the popular idea of easy fiction, a-b-c politics, and how-to-live-on-30-cents-a-day, the circulation strikes an average of the country's population.

How many machinery buyers are there among them all?

Now witness why POWER and other good technical papers can *profitably* advertise machinery and allied things.

The editorial contents of this paper automatically limit the readers of it to men actually interested in the generation and transmission of power.

Those men represent concerns which have the money to buy that machinery which will enable them to make more money!

The circulation instead of being hundreds of thousands is 29,000.

That means a rate in proportion.

The advertiser of power belting, for instance, who spends $4,000 for a single page once in a general medium can buy more than a page in *every* issue of POWER for 52 weeks.

Instead of making the here-today, gone-tomorrow impression, he gets the powerful, cumulative effect of week after week advertising.

Verily, the machinery man who listeth to the lure of the general magazine is putting his shekels where they do him the least good.

It's great to be able to show the family your ad. in "Munbody's;" it's a heap of satisfaction to show the barber, the butcher and the landlord—but, bless you, it doesn't bring home the bacon.

* * * *

Mr. Power Reader, get this point:

The general magazine will take any decent ad.—barring medical, cigarette and liquor stuff—whether for baby's-food or hack-saws. This paper, POWER, won't take anything that isn't by way of being intended for use in a power plant.

That is another reason why you can read the Selling Section through with no danger of wasting your time—with full assurance of finding help in your *business*.

POWER

Vol. 35 NEW YORK, MAY 21, 1912 No. 21

THE value of harmony between power-station department heads in time of emergency was aptly illustrated in a Middle Western power station which serves 32 miles of interurban and street railway lines, a large steam heating system and numerous factories. The boiler room contains eight 500-hp. boilers, the usual coal and ash-conveying equipment and overhead coal-storage bins. The chain-grate stokers were driven by motors located in the basement.

In the engine room are one 1600-kw. turbine, one 800-kw. cross-compound Corliss and two 400-kw. compound Buckeye units.

Due to an excessive rise in the river, the water entered the engine and boiler-room basement on a Sunday morning. Two electrically driven sump and two duplex pumps were put in service to keep the water down, but soon the different departments were asked to help.

The master mechanic of the railway lines secured one 8-in. and one 4-in. centrifugal pump, and three large siphons from different points and delivered them Sunday night. The superintendent of the steam lines soon had his steam fitters connect the pipe lines, and the superintendent of the transmission lines, with his linemen and electricians, connected up the motors operating the pumps and removed all the arc-lighting transformers from the basement and reconnected them to the switchboard, the top of the last transformer being but 2 in. out of water when removed. The purchasing agent promptly arrived at the chief engineer's office to secure the necessary material.

The turbine auxiliaries were motor-driven and as the water entered rapidly but four motors could be removed, leaving five submerged, including the two motor-driven sump pumps. The turbine was therefore shut down and the load put on the engines.

Soon there was $8\frac{1}{2}$ ft. of water in the boiler room basement, and the stoker motors were removed and reset. As the ashpit doors and conveyor were covered over, a boat was placed in the basement and the ash doors were opened under water and spouts arranged under the trip in the loft, the dumping of the buckets aiding in disposing of the water.

By Monday afternoon there was in operation one 8-in. and one 4-in. motor and one 10-in. steam-driven centrifugal pumps, these pumps operating four days completely submerged.

As the oiling systems of all the engines were covered, all the drains were disconnected and the oil taken care of by extra men.

All the exhaust and steam-heating lines were under water, and large volumes of it poured in through the tunnels and drains around the steam-heating mains. The water in the basement was boiling, filling the station with steam.

The bottom of the receiver of the Corliss engine was under 6 ft. of water, therefore it was practically impossible to stop any of the engines because of danger from water in the cylinders. All the rheostats were completely buried.

With all these difficulties to contend with, the service was not interrupted except that the steam heat was off for 18 hours. All the motors were dried out in place, and are running as usual.

Of course, the point of the story is this: The work went on without any friction, because each one did his share and the heads of department worked together in harmony. If this had not been the case, the entire plant would have been shut down.

The Pacific Gas & Electric Co.

By A. R. Maujer

Descriptive and historical sketch of one of the largest public service companies in the world, located in San Francisco.

There are 12 hydro-electric stations and three steam plants which have a total generating capacity of over 131,000 kw.

Contrary to the impression lingering in the minds of many Easterners that the West is still wild and woolly, it is the land of fertile, irrigated valleys where intensive farming and scientific orchard growing are practised, of rapidly developed modern cities and splendid natural resources—it is, in short, the land of promise and progress.

Electricity has played a most important part in this wonderful growth. Cheap power is a cardinal requisite of industrial progress, and when water power is available the cost of power to the consumer is usually lower than where such power is not obtainable. The West has many sources of water power, and almost every community is served by water-generated electrical energy.

In substantiation of this, the writer will describe the development of one of the largest power companies in the world, the Pacific Gas & Electric Co., of San Francisco. Its property value amounts to over $100,000,000 and the gross earnings in 1911 were upward of $14,000,000. The company is a consolidation of numerous electric power, gas and water companies located in and near San Francisco. It owns property and operates in 30 counties of California, representing an area of nearly 38,000 square miles, and supplies 204 cities, towns and villages containing two-thirds of the entire population of the state. There are 12 hydro-electric generating plants ranging in size from Alta, of 500 kw., to Electra, of 20,000 kw. capacity, and three steam-generating plants, Station A, in San Francisco, of 38,000 kw., Station C, in Oakland, of 21,000 kw. and Station A, in San José, 2300 kw. capacity.

The map in Fig. 1 shows the location of the various power houses and the main distribution lines.

Folsom Plants

Chronologically, the first power houses to mention are those at Folsom, on the American River, by the water of which the generators are driven under the low heads of 55 ft. at the upper power house and 26 ft. at the lower. The upper plant was completed in September, 1895. Its equipment at that time was of 250 kw. capacity. Current was generated at 800 volts and stepped up to 11,000, at which voltage it was transmitted 22 miles to Sacramento to run the street railway and supply light and power to private consumers. The transmission voltage has since been increased to 60,000 volts. The combined capacity of the two plants at the present time is 3771 kw., divided among five units.

The feature of these plants is the low head as contrasted with the very high heads at many of the other plants throughout the West. During the dry season the upper plant uses practically the entire flow of the American River, of 70,000 miner's inches.

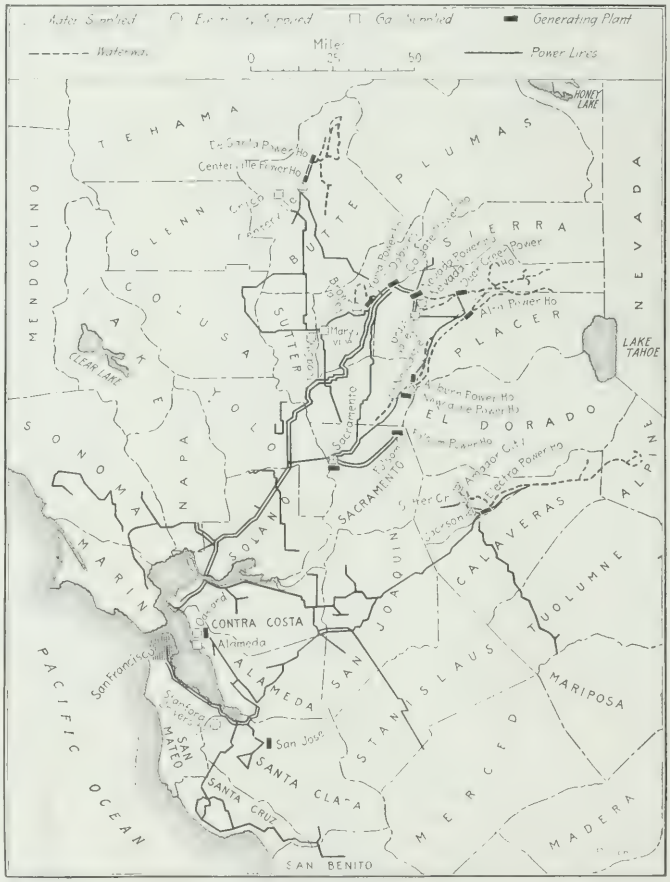


Fig. 1. Map Showing Location of Power Plants and Transmission Lines

Nevada Plant

Next in order comes the Nevada plant, on the South Yuba River, which really dates back to 1891, although current was not generated until 1896. In the former year an effort was made to put a diverting dam of logs across the river, but the work was swept away by the freshets of the next spring. The next attempt at building a dam, made in 1895, was successful and the plant was put into service during the next February. The original equipment consisted of two 300-kw., 133-cycle, two-phase Stanley generators direct-connected to Pelton impulse wheels. In 1898 a crib dam 54 ft. high and 327 ft. long was constructed in Rock Creek east of the power house to back water up into a partially excavated basin which had previously been the scene of some gold dredging. The water thus stored is called Lake Vera. The capacity of this storage basin is 22,500,000 cu.ft.

The present equipment, of four units,

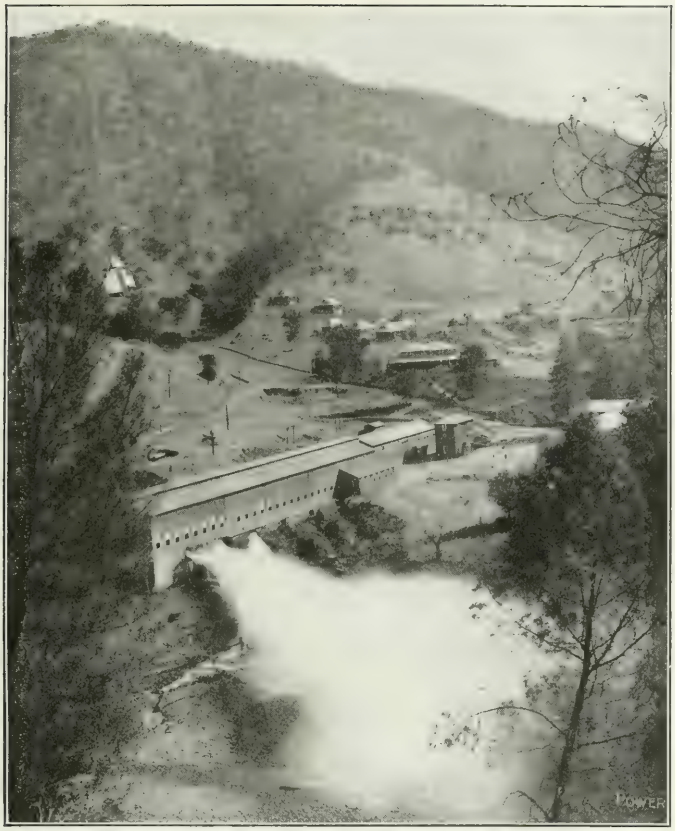


FIG. 2. THE ELECTRA PLANT ON THE MOKELUMNE RIVER

of the Nevada plant has a capacity of 1267 kw.

ELECTRA POWER PLANT

The most important of the hydro-electric plants of the Pacific Gas & Electric Co. is Electra, which is located about 100 miles northeast of San Francisco, on the Mokelumne River. The first installation, in 1902, consisted of five 2000-kw. generators direct-connected to impulse wheels operating under a head of 14,067 or 12,067 ft., as desired. The present equipment includes two additional units each of 5000 kw. capacity, and current is generated at 2300 volts and stepped up to 60,000 for transmission.

The extensive water supply of this plant and the storage arrangement make continuous operation practically an assured thing so far as water supply is concerned. The storage reservoirs cover an area of some 950 acres and have a capacity of 1,079,903,000 cu.ft.

About 65 miles above the plant and high in the Sierra Mountains at an elevation of over 8000 ft. is a group of six lakes known as the Blue Lakes, which forms the head waters of the Mokelumne River, and incidentally storage reservoirs for Electra.

Twenty-five miles above the plant a diverting dam was built in the river and 5000 miner's inches of water are taken out and conveyed through a ditch known as the "Upper Standard Canal" along the mountain-side to a point above the power house where it is received in a small reservoir known as the Petty reservoir. Near the inlet of this little reservoir a flume branches westward carrying water to the mines in Amador City, Jackson and Sutter Creek. Along this ditch are three minor reservoirs, New York reservoir, Tanner reservoir and Amador reservoir, which have a combined capacity of 4,600,000 cu.ft. and serve to maintain the supply to the towns if anything goes wrong with the flume system.

When the demands for current grew beyond the original expectation, a second dam was built at a point two miles below the first and another ditch, known as the "Lower Standard Canal," brought more water down to the plant. This canal lies practically parallel with the first one for its entire length, it being built along the mountain side at an elevation 200 ft. below that of the first.

A storage reservoir for the excess water brought down in this canal was formed on the other side of the ridge from the plant by constructing a high, earth-filled dam at one end of a wide ravine. Thus to get the water over onto the power-plant side of the ridge a 3000-ft. tunnel was dug. This reservoir

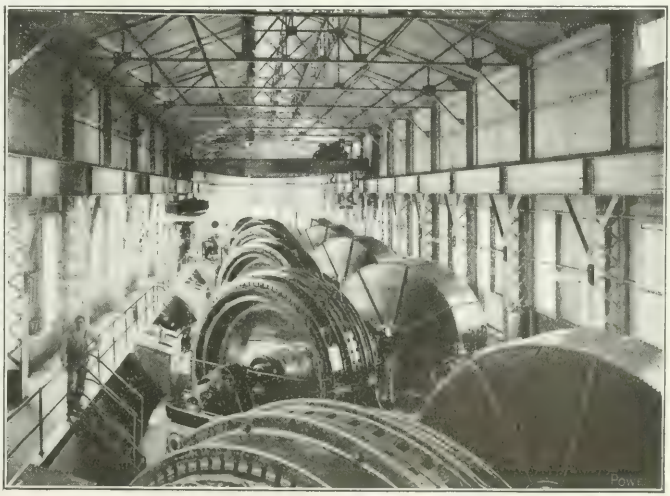


FIG. 3. ORIGINAL UNITS IN ELECTRA STATION

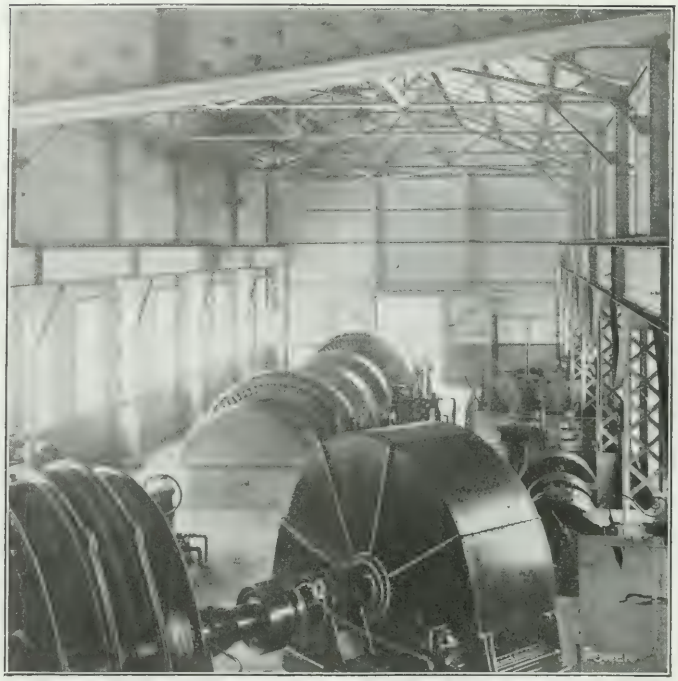


FIG. 4. EXTENSION OF ELECTRA PLANT, SHOWING TWO NEW UNITS

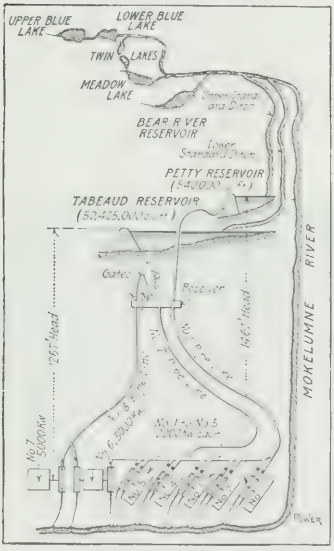


FIG. 5. SKETCH OF ELECTRA WATER SYSTEM

is known as Lake Tabeaud, has a capacity of 50,400,000 cu.ft. and covers an area of nearly 40 acres.

The water from both Petty reservoir and Lake Tabeaud passes through a receiver-manifold as shown in the free-hand diagrammatic sketch in Fig. 5. By this arrangement it is possible to run all the generators on either the high or low head in case of temporary trouble with either canal, and the storage capacity of Lake Tabeaud is sufficient to supply the plant for several days if operating difficulties arise on both canals.

YUBA POWER PLANT

In April, 1898, the Yuba plant was erected at the head of Brown's Valley, on the middle fork of the Yuba River. The present capacity of this plant is 664 kw., in two units. The water for the plant is obtained from the main ditch of the Colgate plant, later to be mentioned, the water entering what is known as Brown's Valley ditch. After passing through the wheels in the Yuba plant the water again enters Brown's Valley ditch and is conveyed to Brown's Valley, north of Marysville, where it is used for irrigation purposes. The construction of the Colgate power plant on the same river, at a point called Missouri Bar, was completed in September, 1899. The original capacity was three 900-kw. generators and the current was transmitted 76.3 miles to Sacramento at 40,000 volts. This was the longest transmission line in the world at the time of its erection. The present capacity of the plant is 15,000 kw.

Colgate obtains its supply of water from a flume 7.6 miles long which has a capacity of 15,000 miner's inches. Water is taken from the river eight miles above the plant and brought to a point on the mountain above the power house, where it enters the pressure pipes 1625 ft. in length, giving a static head at the plant of 700 ft. As a safeguard, additional water for Colgate is stored in an artificial lake known as Lake Frances, at the head of Dobbins Creek, just above the power house. This lake has a capacity of 110,000,000 cu.ft. and by means of a rapid flume 8500 ft. long with a 300-ft. fall, it feeds into the penstock of the plant. Current from this plant was first brought 140 miles to Oakland

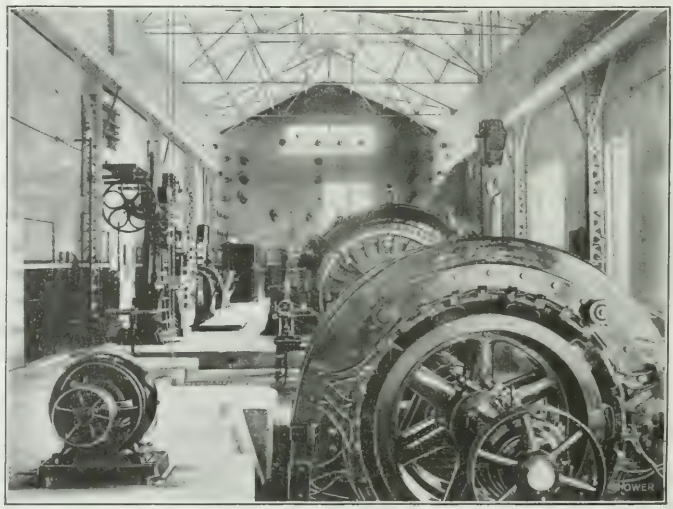


FIG. 6. INTERIOR VIEW OF CENTERVILLE PLANT

by way of the Straits of Carquinez. In crossing the straits the cables spanned the enormous distance of 4427 ft. between supporting towers of such a height as to give a clearance of 206 ft. above the extreme high-tide level.

Centerville and DeSabla Plants

In history and development the Centerville and DeSabla plants are more or less closely connected. Centerville, erected in 1900, is located on Butte Creek in the bottom of a cañon of the same name. The DeSabla, erected in 1903, is located 5½ miles higher on the same stream at a point just above the diverting dam which turns the water into the ditch of the Centerville plant. The static head at Centerville is 577 ft. The equipment consists of one 900-kw. generator driven by an impulse wheel and one 5500-kw. generator driven by a water turbine. At DeSabla there are two 2000-, one 4000- and one 5000-kw. generators, all driven by impulse wheels. The head at this plant is 1531 ft. Current is generated at 2400 volts and stepped up to 60,000 for transmission. At Centerville the older unit generates at 2300 volts and the new one at 2400.

The DeSabla plant utilizes water derived from Butte Creek and the west branch of the Feather River, 54 miles of ditch and flume being required to bring the water down to the head works of the plant.

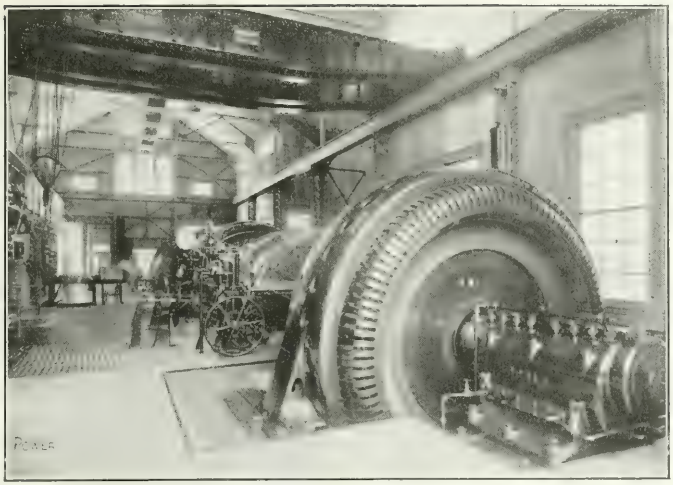


Fig. 8. Interior View of the De Sabla Plant

Central California System

Among the numerous hydro-electric companies absorbed by the Pacific Gas & Electric Co. was the Central California Electric Co., which operated two small hydraulic plants, one at Auburn and the other at Newcastle, in Placer County. In 1900 a third power house was built at Alta, also in Placer County; the original transmission line, extending from the Auburn and Newcastle plants to Sacramento, carried current at 15,000 volts. Upon the completion of the Alta plant the potential was raised to 30,000 volts, while at the present time it is 60,000. In 1908 the fourth plant of this group was erected at Deer Creek, in Nevada County.

At Auburn, the equipment consists of a 500-kw. generator driven by an impulse wheel under a head of 206 ft. At Newcastle, two 400-kw. generators driven by impulse wheels under a head of 464 ft.; at Alta, three 1000-kw. generators, operated by Girard type turbines under a head of 660 ft., and at the Deer Creek plant the equipment consists of a 5500-kw. generator driven by two impulse wheels under a head of 837 ft.

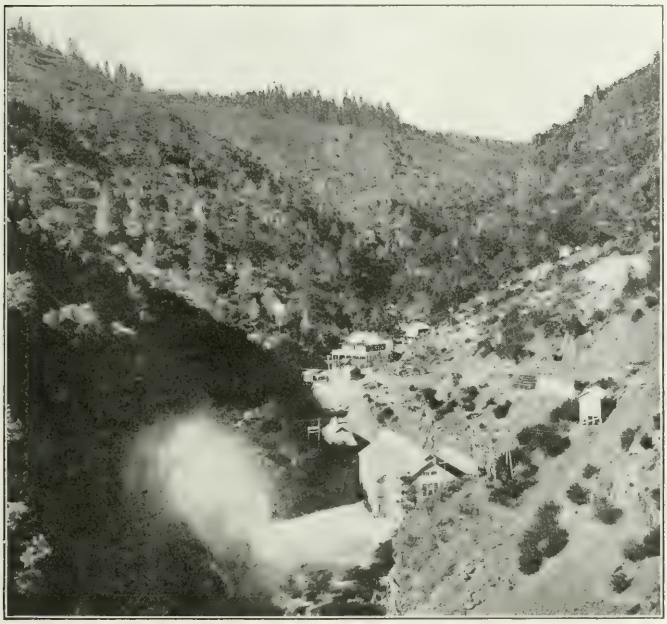


Fig. 7. De Sabla Plant in Butte Creek Canyon

Steam Relay Plants

The Pacific Gas & Electric Co. owns four relay plants, three of which are equipped with steam-driven units and one is equipped with gas-driven generators. Of these the more important are Station C, in Oakland, and Station A, in San Francisco. The third steam plant, at San José, is of small size, having a capacity of only 2300 kw., and contains units of more or less obsolete design and arrangement. It was built and originally operated by the United Gas & Electric Co. and since being taken over by the Pacific Gas & Electric Co. it has been used only as an auxiliary. The gas-engine plant is not operated at the present time because of operating difficulties.

Station C, Oakland

The rapid development of Oakland, located just across the bay from San Francisco, has led to the extension of Station C, which came into the possession

of the company through the acquisition of the Oakland Gas, Light & Heat Co. The plant is at First and Jefferson Sts., on the waterfront, where fuel oil can be secured at minimum cost of handling and where sea water is conveniently available for condensing purposes. The original station contains eight McNaul oil-burning water-tube boilers rated at 750 hp. each, capable of 40 per cent. overload, and a 9000-kw. General Electric generator driven by a Curtis vertical turbine.

The new unit also is composed of a General Electric generator and a Curtis vertical turbine. It has a capacity of 12,000 kv.-a.

The new boiler equipment will consist of four 750-hp. Parker boilers and superheaters, these boilers being capable of carrying a 60 per cent. overload which gives a total capacity of 4800 boiler horsepower, equivalent to upward of 10,000 engine horsepower.

The condenser for the new unit is a Worthington surface, two-stage, turbine-base type, having 25,000 sq.ft. of cooling surface. The new circulating-water pump built by the Byron & Jackson Co., is of the centrifugal type and has a capacity of 40,000 gal. per minute.

The hotwell pumps are a Worthington turbine-driven, two-stage and a Worthington motor-driven, two-stage turbine pump. The feed pump is of the four-stage turbine type and was made by the Alberger Condenser Co.

This station may be operated either in parallel with the main transmission lines coming from the hydraulic plants or separately on the Oakland load.

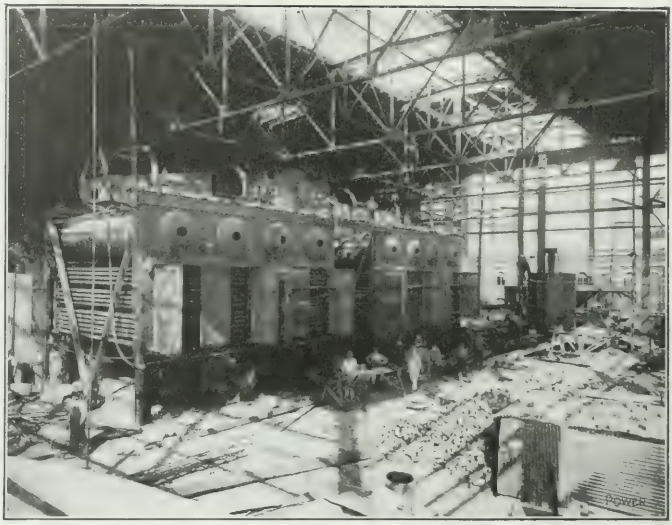


FIG. 9. BOILERS AT STATION C IN COURSE OF ERECTION

STATION A, SAN FRANCISCO

The largest and most important of all the stations of the Pacific Gas & Electric Co. is Station A, in San Francisco, located between Humboldt and Twenty-third streets, on the waterfront.

Originally this station contained 10 main units; five of the engines, built by McIntosh & Seymour, were vertical

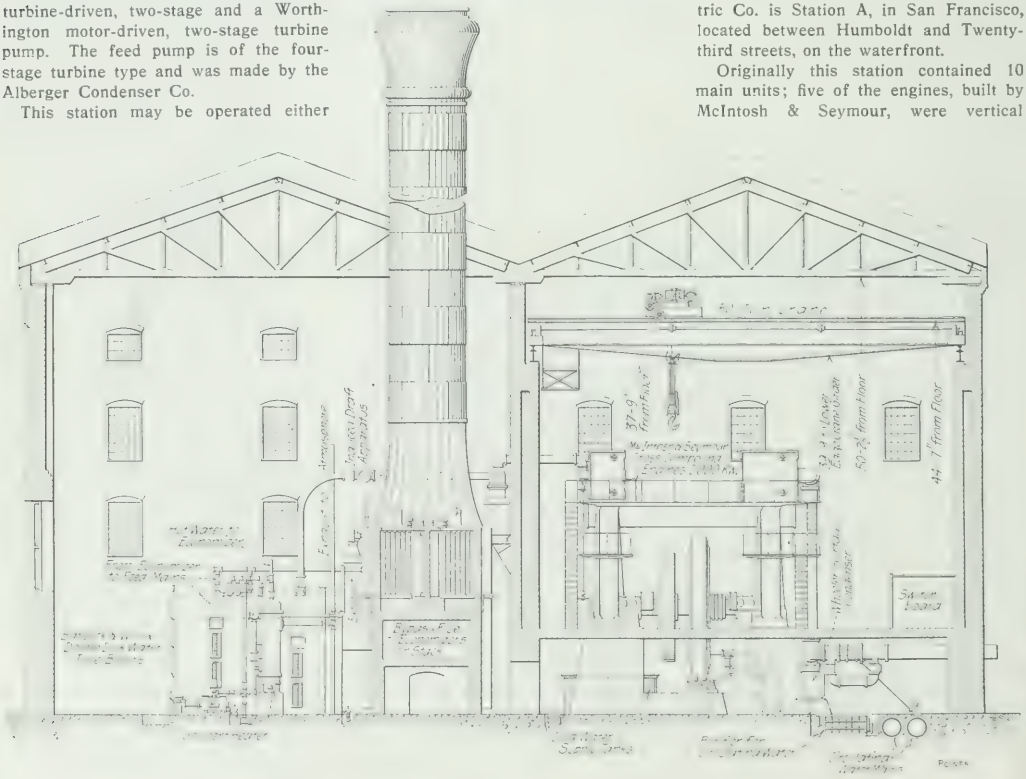


FIG. 10. SECTIONAL ELEVATION THROUGH STATION A, SHOWING LAYOUT OF PLANT

ross-compound condensing, 2000-kw. nits, 28 and 58 by 48 in. in size, running t 116 r.p.m. One of these engines was emoved in 1910 and a 15,000 kv.-a. Curtis turbo-generator was installed in ts place. The balance of the equipment nstalled and still in service is composed f one 800-hp. McIntosh & Seymour ver- ical cross-compound engine, 17 and 34 y 36 in. in size and running at 116 .p.m.; two 2500-hp. Union Iron Works ertical, triple-expansion condensing en- ines, 26, 38 and 56 by 48 in. in size, unning at 140 r.p.m.; two 6000-hp. Jnion Iron Works vertical, triple-expan- ion, condensing engines, 36, 58 and 90 y 48 in. in size, running 106 r.p.m.

The building, which was completed ome 12 years ago, is 450 ft. long, 140 t. wide and 80 ft. high; the side walls

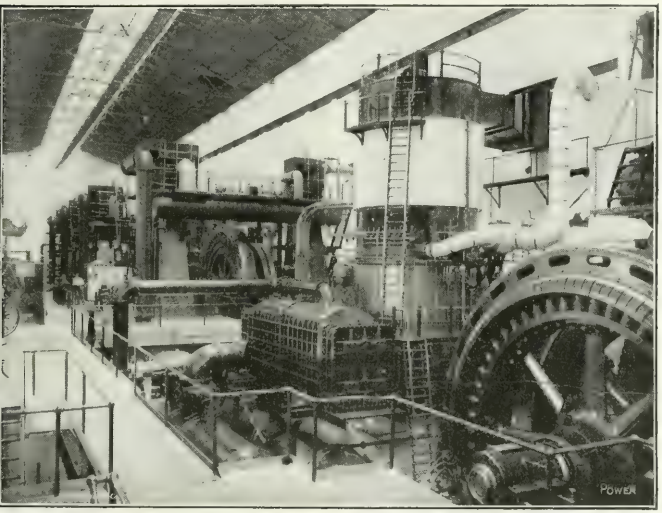


FIG. 11. INTERIOR VIEW AT STATION A, SHOWING NEW TURBINE UNIT

re of brick and the roof is of steel overed with sheet iron.

The boiler equipment is as follows: fteen 550-hp. B. & W. units, six 680-hp. . & W. units and six 640-hp. Heine nits. Ten of the 550-hp. units have een fitted with Foster superheaters for iving the steam for the turbine a super- eat of 100 deg. The steam pressure is 75 lb. The fuel oil is brought to the tation in tankships and pumped into the torage tanks on the premises, which ave a capacity for enough oil to keep ne station in operation for 30 days.

The 15,000-kv.-a. turbine unit, which as put into service in January, 1911, rings the total capacity of this station p to approximately 38,000 kw.

For the information contained in the oregoing and for the personal courtesy xtended to him, the writer is indebted to ne members of the operating department f the Pacific Gas & Electric Co.

Saving the Heat Units

By J. C. Hawkins

In a certain isolated plant quite a saving was made by using the hot air for combustion from over the boilers in the furnace instead of cold air. The boilers take up the full width of the room, leaving about 4½ ft. head room between the tops of the boilers and the ceiling.

These four boilers in the plant use forced draft supplied by a 7-ft. fan set in a hall outside the boiler room as that was the only available place. As first installed this fan received its air supply from the hall at an average temperature of about 75 deg.; the temperature of the air above the boilers was from 140 to 175 deg.

Some time ago it was decided to house in this fan and take the air supply from above the boilers at the higher temperature. A brick wall was built around the fan and engine, with large doors so located that all parts of the machine would be accessible. With this arrangement the temperature of the air supply is kept at about 120 deg. It cost about $200 to make the change.

The plant uses about 4000 tons of coal per year costing $3.30 per ton and having a calorific value of about 14,000 B.t.u. per pound. It is estimated that 24 lb. of air is used per pound of coal and a saving is made because with the present arrangement less heat is required to bring the temperature of the entering air up to that of the flue gases, which is about 500 deg. This saving may be estimated by multiplying together the weight of the air per pound of coal, the specific heat of air and number of degrees difference in temperature. The specific heat of air is approximately 0.24. Thus the saving would be,

$$24 \times 0.24 \times (120 - 75) = 259 \text{ B.t.u.}$$

per pound of coal, or

$$\frac{4000 \times 2240 \times 259}{14{,}000} = 165{,}760 \text{ lb.}$$

or 74 tons of coal per year, which cost $244. Thus it will be seen that the investment is more than repaid each year.

The air for the furnaces could be had at a temperature somewhat above 120 deg., but the bearings of the fan and engine run rather warm at this temperature, and as the speed is high at times of heavy load it was thought best to open one of the doors a little, thereby admitting some cold air rather than risk melting the babbitt in the bearings.

Although great care has been taken to insulate the header and steam pipes, the smoke flue and the tops of the boilers, there is a great deal of heat radiated and much of this is saved which would otherwise be wasted. The space above the boilers is closed on the front and both sides, the rear end only being open and communicating directly with the engine room, the rear end of the boilers forming one end of the engine room. In addition to the draft fan, the air from this area is carried away by two 36-in. disk fans which discharge outside the building and with the draft fan gives fairly good ventilation to this space as well as the engine room, the air being drawn from the halls through the engine room and thence over the tops of the boilers to either the draft fan or ventilating fan as the case may be.

As the front of the boilers is closed up with the stokers there is very little heat radiated out in front, and good ventilation is had from the hall, making the boiler room about the coolest place around the plant. When working on the boilers with the fans running, the men do not suffer as they otherwise would.

The statistics of coal production in Maryland, collected by Edward W. Parker, of the United States Geological Survey, in coöperation with the Maryland Geological Survey, show that the total production in 1911 amounted to 4,685,795 short tons, valued at $5,197,066. Compared with the production in 1910, the output in 1911 showed a decrease of 531,330 short tons, or 10.2 per cent., in quantity, and of $637,992, or 10.9 per cent., in value. Stimulated by the strike of miners in the Middle West, Maryland in 1910 increased her production nearly 1,200,000 tons over 1909, and a part of the markets secured at that time were held in 1911, but not sufficiently to maintain the tonnage of the preceding year. The coal mines of Maryland gave employment in 1911 to 5981 men, who worked an average of 243 days, against 5809 men for an average of 270 days in 1910.

Compressed Air Pumping Systems*

By Frank Richards

With direct-displacement pumps the efficiency, although low, is better than with steam pumps, because friction and clearance losses are reduced.

With return-air systems the efficiency is greatly increased because only the actually required pressure and volume are used.

*Continuation of article in the May 14 issue, entitled "Raising Water by Compressed Air."

Direct Displacement Pumps

Naturally, the first arrangement thought of when it is proposed to use compressed air for pumping water is that in which the water is displaced volume for volume by the air, which is compressed to a pressure corresponding to the height of the lift, and this scheme has been worked up in a great variety of ways but with little variation of result.

Fig. 1 shows diagrammatically a pumping apparatus of this type. The submerged chamber here shown is assumed to have been filled with water and this water is now being expelled by air pressure. The air comes direct from the compressor, passes the three-way valve and enters the top of the chamber, its pressure driving the water up the vertical pipe at the right. When the water is all expelled, the three-way valve is changed to the other position, shutting off the compressed air and opening communication between the interior of the chamber and the atmosphere and allowing the air to escape. Then the valve in the water pipe at the upper right-hand corner of the submerged chamber closes by its own weight and the pressure of the water above it, and the water rushes into the chamber through the valve at the bottom. A reversal of the three-way valve to the position shown puts the compressed air at work again and the content of the chamber is expelled as before, and so on. The three-way valve is usually operated by a float, making the operation automatic. There are generally two of these displacement chambers, which work in connection, the same valve-operating mechanism serving for both, and thus as one is filling while the other is discharging, the water flow is almost continuous.

It is well understood that the displacement pump does not use the air to good advantage, but for economy it is still much better than the air-driven, direct-acting pump. There is no friction of reciprocating parts and the clearance losses are very small, so that instead of the 20 and 20 per cent., which is allowed for the direct-acting pump, a single 10 per cent. will fully cover these items, leaving at this stage 90 per cent. instead of 64. The loss for the same pressures in not using the air expansively would, of course, be unchanged, and therefore the 34 per cent. which was assumed would still apply, and 34 per cent. of 90 being 30 there is 60 per cent. efficiency for the displacement pump instead of the 43 per cent. of the air-driven, direct-acting pump, and 57 per cent. instead of 41 per cent. when the air leaves the compressor.

The economy of the displacement pump is much better where the lift is small, which makes it specially applicable for transferring sewage and similar service, especially as the water may be loaded with a large proportion of solids and semi-solids without impairing its action.

Return-air Pumping

The progress of invention in any line seems to be one of gradual but continuous revelation and development.

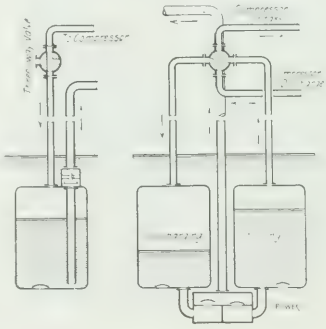


Fig. 1 Fig. 2

Every device, so that it will work at all, seems to have a right to be completely tried out, and to have all its possibilities and its defects revealed before it can expect to be and actually is displaced by something better.

When the power-wasting and otherwise objectionable direct air-pressure, water-raising apparatus has had its every chance and has been found wanting, then, and not until then, comes another device which is at once hailed as just what is needed. The principle of it is at once self-evident, and its perfect success when applied requires no practical demonstration.

This is the return-air system of compressed-air pumping. Its operation, in contrast to that of the direct-displacement pump, is that while the old pump will take all the air that is given to it for raising and delivering a given weight of water, and will return absolutely nothing of what it receives, this new device will take only the pressure and volume of air which exactly pays for the work done, and, so to speak, it returns all the change.

The whole thing can be simply explained, the diagrammatic sketch in Fig 2 perhaps assisting. It must be premised that a return-air system is not a cheap and handy little device ready to go, for instance, wherever a steam pump might be employed, and to do the same work; it is intended for large and permanent installations, each plant being complete in itself and doing no other work.

The Apparatus Used

There is, first of all, an air compressor whose entire business it is to operate the one pump, the capacities of the pump and compressor being adapted to each other. There is nothing special about the compressor except that it is a single-stage, reciprocating machine, and it of course, may be driven by any available style of power transmission and application.

The pumping part of the apparatus consists of two similar chambers to be alternately filled with water and emptied by the expulsion of the water to the level required. These chambers are submerged in the water to be pumped, or at least are located near and below the lowest working level of it, so that the water will always be able to flow into either chamber by gravity. The compressed air is conveyed to the pump from the compressor by separate pipes to each water chamber, and each pipe also leads the air, after its work of water expulsion is done, back to the air intake of the compressor. It is thus a closed system and the same air is used over and over again, provision being made for continually replacing the little that may be lost by leakage or by absorption in the water. The valve arrangements are clearly shown in Fig. 2.

Operation

Assume that the pump is actually at work, that one of the chambers is full of water, with sufficient air pressure flowing in at the top of the chamber exerting its pressure upon the water and driving it through a retaining valve and up a water pipe to the point of delivery.

Thus far the operation is precisely the same as with any displacement pump and when the water is all, or nearly all, driven out the chamber is full of air at the pressure required and determined by the height of the water delivery. The regular operation by the old way would now be to close the communication with the compressor and to open another

e atmosphere, allowing the air, ex-nding as it goes, to escape without oing any more work and leaving the amber filled with air at normal at-ospheric pressure. Water is then al-wed to flow in and to fill the chamber gain, which drives out the remainder e former charge of air, and this cham-rful of water is driven out and up another charge of full-pressure air before, and so on.

With the return-air system, however, e air is not let off so easily, but is tained to do a lot more work. The r is discharged from the water cham-er and up the air pipe which, by the ction of an automatic or a positively erated switch, is now in connection ith the intake instead of the discharge the compressor, and whatever pres-ure this air may have is thus always eing exerted upon the intake side of e compressing piston, and the pressure on this side overcomes an equal mount of resistance upon the com-ressing side of the piston, or it deducts st so much from the total power re-uired to drive the piston and to do the ork of recompression.

Using the air in this way, its entire xpansive force is retained upon the edit side of the system. Expansion ntinues until the air pressure is lower an that of the water which is waiting enter, the difference of these pres-ures depending upon the speed at which e system is being driven, and then the ater enters and drives the remainder f the air into the compressor intake this pressure instead of letting it fur-er expand, and thus raises the total ean effective assisting pressure at the ack of the piston above that which would ave resulted from the expansion alone.

Each return-pipe installation is an in-ividuality, with special conditions to be atisfied and calling for special sizes nd capacities, both relative and actual. he system is advantageously applicable both extremes of the possible range f practical requirements, and to all be-ween.

Constant Lift System

Where the lift is practically constant, s in raising water from a lake or river a water-works reservoir, the com-ressor and the pump may be so adapted capacity as to utilize all the expan-ive force of the air with comparatively ttle of the follow-up pressure from the ater, but still with the highest possible ltimate efficiency and economy. In any ase, as the compressor is in immediate uch with its work there is no loss from vercompression or from compressing bove the actual requirement, as is often ne case with the direct-displacement ystems.

Variable Lift System

If the return-air system is employed here the level of the water intake has a considerable variation of height, as in emptying a large, deep shaft of a mine, the follow-up pressure of the water in refilling the operating chambers will vary constantly with the water level, and at all levels will approximately adjust the work of the compressor according to the actual water lift at the time; and, although the water must always be lifted under the full actual head at the time, and with the requisite over-balancing pressure for the expelling air, the compressing of the air to that pressure will require little or much power according to whether the return, or intake, pressure at the compressor is much or little, corresponding to the height of the water supply. With the direct displacement, and no return of the air, there would be none of this compensation, either from the reëxpansion of the air or from the follow-up pressure of the incoming water, and all the water lifted, whether the level of the supply was high or low, would require the maximum and entirely uncompensated pressure to raise it.

An Example of Application

There was a case where it was necessary to provide, and to have constantly ready the means of emptying a shaft of considerable area, more than 300 ft. deep and normally full of water, with a tunnel at the bottom of the shaft also to be emptied. This will be recognized at once as a problem easy enough of solution, in a way, but not so simple when speed and economy were to be considered. There had been actually installed for this work a hoisting engine and a large cylindrical bucket, say 4 ft. in diameter and 12 ft. long, to be successively filled, hoisted and emptied.

This might strike one as a rather primitive arrangement, but it had at least the merit of using the power with reasonable economy. The varying height did not at all affect the weight of the bucket of water, and the power consumed was therefore always directly as the height, and with engines showing good steam economy the arrangement was not wasteful of power. This bucket arrangement was actually used for emptying the shaft and tunnel once and it worked all right, but nevertheless it was superseded by the return-air system, which could show good power economy and could do the required work in much less time, which in this case was the all important consideration

The shaft here spoken of is known as shaft 25 of the "new" Croton aqueduct, and the tunnel is the portion of the aqueduct which crosses under the Harlem River, 300 ft. below its surface, near Washington Bridge, New York City.

Valve Arrangement and Operation

In the foregoing outline of the operation of the return-air system reference has been made only to the action in one submerged operating chamber. It is understood that there are two similar chambers operated alternately, one filling while the other is emptying, so that the lifting is practically constant. The four-way valve or switch, as it is called, for reversing the connections of the two pipes at the proper times is operated in different ways according to the work. For a straight, steady water-works job the switch may be operated mechanically, tripping one way or the other for each given number of revolutions of the compressor; it may be operated automatically by the fluctuations in the level of the water supply, and it may also always be operated by hand. It is not necessary to completely fill either chamber before reversing because the unused pressure is not lost in any case, and there is nothing corresponding to the clearance losses in the direct-pressure ejection system.

The actual installations of the return-air pumping system already show a wide and interesting range of successful employment; what the device needs most of all is to be better known. It seems to decline no job which is possible by any system, and it works for the lowest air output, and is especially successful in many lines which are not permissible to the formal mechanical devices. It pumps, for instance, water which is so charged with solid matter that it can only be called semi-liquid. It is in some cases regularly employed for conveying the solids so contained, as sand or marl, the mixture when so raised going to settling tanks where the water is allowed to flow off, leaving the solid portion to be shoveled or otherwise handled and conveyed wherever required.

A tribute to the importance of the field we humbly serve has been rendered by our popular contemporary *Scribner's Magazine*. The current number has two leading articles on hydraulic power. One deals with locating and developing available powers, and the other with the present application of water power in the United States. Two other articles concern notable works in the transmission of water, though not for power—from the Sierras across the Mojave Desert to Los Angeles, and the siphon tunnel, the deepest in the world, under the Hudson River for the New York City aqueduct. We extend the right hand of fellowship in greeting to our new competitor.

The "Queen Mary," the latest and largest of Great Britain's dreadnoughts, has a displacement of 27,000 tons and an indicated horsepower of 75,000. Many changes have been made in her engines and boiler room to avoid the excessive heating that occurred on the "Lion."

Pyrometers and Boiler Efficiency

By C. F. Busse

Boiler efficiency depends greatly upon the relative temperatures of the flue gases before and after coming in contact with the heating surface. Hence, suitably placed pyrometers make it possible to regulate boiler operation to secure best economy.

Progressive and observing power-plant engineers recognize the fact that there is more room for economy in a boiler house than in any other part of the plant. In most of the power plants from 5 to 25 per cent. of the available energy of the fuel is needlessly wasted, due to ignorance of what is actually taking place in the boiler furnace.

The efficiency of any steam generator is the ratio of the heat utilized to that supplied, and depends upon complex conditions, many of which are changing. Some of them are:

Humidity of the atmosphere.

The quality of fuel, which, even at its best, is never quite uniform, as it may vary in its moisture content, fixed carbon, volatile matter, oxygen, hydrogen and ash and, unless specially prepared, its physical conditions may vary from large lumps to fine powder.

The condition of the boiler as to setting, dirty or clean heating surface, draft, air infiltration, etc. The grates may become choked with slate and clinker, obstructing the air passage and causing irregular flow, resulting in a deficiency of air in one place and an excess in another.

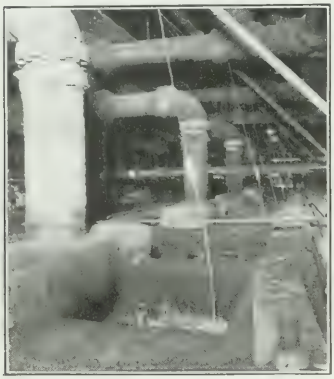


FIG. 1. THERMO-ELECTRIC PYROMETERS APPLIED TO STEAM BOILERS

The required output which varies in some plants from 50 per cent. below normal capacity to 50 per cent. overload in short intervals of time.

From the foregoing it is quite evident that no matter how well a boiler may be designed or perfectly constructed, it is impossible—due to the changing conditions just mentioned—permanently to adjust it, as in the case of a steam engine, to operate at maximum efficiency.

HEAT DISTRIBUTION IN BOILER

The heat generated in a boiler furnace is dissipated in three ways, some passing up the stack with the waste gases, thus supporting the draft; some being utilized in the evaporation of the water, and some being lost through radiation. From a well designed boiler, properly set, the radiation is always small, usually being less than 5 per cent. The heat in the gases passing up the stack is necessarily lost for evaporation effects, but essentially so to maintain draft unless

FIG. 2. PYROMETERS APPLIED TO ECONOMIZERS

artificial draft is provided. In general practice the heat carried off by the flue gas is rarely as low as 15 per cent. and often reaches 40 per cent. of the calorific value of the fuel. This loss is made up of two distinct factors: The sensible heat of the flue gases and the potential heat of the combustible constituents of the flue gases. The former varies directly as the stack temperature, while the latter depends greatly upon the amount of air admitted to the fire.

CALCULATION OF BOILER EFFICIENCY

In burning coal in a boiler furnace, the specific heat of the gases of combustion passing over the heating surface and through the uptake varies slightly. However, for practical purposes, this may be assumed to be constant, as the error in calculating efficiency thereby is not a serious one. Neglecting the loss by radiation, the percentage of heat utilized—that is, the efficiency of the boiler—may be calculated by the formula

$$\frac{T}{T}\quad\frac{T_1}{T_a}$$

where

T_1 = Temperature of the gases of combustion just before they first come in contact with the heating surface;

T_e = Temperature of the gases of combustion just as they leave the heating surface in the last pass;

T_a = Temperature of the air.

The following was taken from data obtained in a 24-hour test conducted by the writer on a 350-hp. Stirling boiler, equipped with a Green chain grate and served a 175-ft. chimney; the ratio of heating surface to grate surface was 42.5 to 1; the average running pressure was 110 lb., gage:

Steam pressure, gage	110.5 lb.
Temperature of the fire	2375
T_1	1810
Temperature in the second pass	1150
T_e	550
T_a	81°

One hour later, the data were:

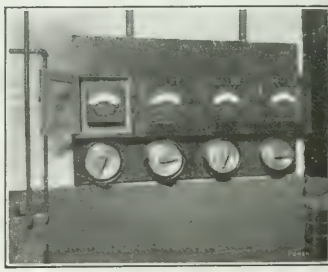


FIG. 3. INDICATING GAGES OF A PYROMETER INSTALLATION

Steam pressure, gage	107.5 lb.
Temperature of the fire	2065
T_1	1650
Temperature in the second pass	885
T_e	545

Substituting from the foregoing data in the formula, we have

$$\frac{1810 - 550}{1810 - 81} = 72.8\%$$

$$\frac{1650 - 545}{1650 - 80} = 70.4\%$$

Let it be assumed that the conditions of the boiler remained the same in all respects but one—i.e., either the temperature of the first pass had changed (the other conditions remaining the same) or that the breeching tempera

ture had changed; all other conditions, including the first pass temperature, remaining the same.

In such a case, and substituting in the above formula, the results would indicate that the heat utilized increases with an increase in temperature in the combustion chamber; that the heat utilized increases as the temperature of the waste gases decreases; that there should be sufficient heating surface to cool the gases as much as possible before they escape, although enough heat must be left to create a draft in order to burn the fuel.

Relation between Flue Gas Temperature and Efficiency

Experiments show that an increase or decrease of 30 deg. F. in the waste gases, all other conditions remaining the same, means an increase or decrease of 1 per cent. in efficiency.

Where CO_2 recorders and temperature-indicating devices have been used on a boiler, it has been shown that there is a close relationship between the temperature of the flue gases and the percentage of CO_2 contained in them. It has been found that the higher the temperature in the combustion chamber, the higher was the average percentage of CO_2. On the contrary, however, it has frequently occurred that when the furnace was run so as to produce a maximum percentage of CO_2, the temperature of the gases of combustion in the fire chamber decreased; being caused by incomplete combustion, due to a minimum of free oxygen, and thereby reducing the efficiency.

If each boiler in a plant be equipped with a temperature-indicating device, making it possible to ascertain the temperature in the first, second, or last pass or whenever else desired, the fireman has an accurate heat analysis of his boilers and he is able to know the condition of the furnaces and boilers under his charge, viz.: Whether the fires are dirty, the fires have holes in them, the boilers are dirty inside or outside, the baffles in the boilers are breaking down, thus short-circuiting the gases.

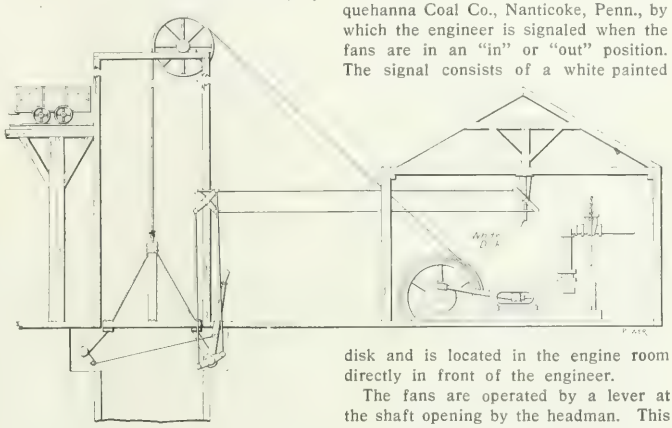
Inasmuch, however, as the most economical temperatures vary considerably with the kind of fuel used, and to some extent with the method of firing, hand or mechanical, the kind of stoker, rate of driving, and the depth of fire, occasional tests in which the effects of these factors are determined, are of great value to the fireman.

Pyrometers in Connection with Economizers

The temperature at which the feed water is fed to the boiler is an important factor in boiler-plant economy. In many plants the waste gases of combustion are used to heat the feed water, this is done in what is known as an economizer. By placing temperature-indicating devices where the flue gases enter and leave the economizer, it is possible to ascertain the drop in temperature between the inlet and the outlet, thus showing the condition and efficiency of the economizer. This, however, is not the only advantage; if the economizers get out of order, because of their construction, it is almost impossible to detect the fact without the use of a temperature indicator. Economizers have shown an absorption producing a temperature drop of 100 deg. F. more when clean than dirty.

The Thermo-electric Pyrometer

One of the most practical instruments for taking temperatures in a boiler furnace is the thermo-electric pyrometer. The principle upon which the thermo-electric pyrometer is constructed is the measurement of a current of electricity produced by a thermocouple, composed of two dissimilar metallic elements, by



Arrangement of Shaft Fan Signal

means of a galvanometer or millivoltmeter calibrated in degrees of temperature instead of units of electricity.

Where a battery of two or more boilers is equipped with pyrometers and working with a capacity load, it is possible to detect which boiler is carrying the larger part of the load. A pyrometer installation, equipped with a switch whereby a number of thermocouples may be connected to one indicating instrument, makes it possible to so supervise the boilers that each will carry its share of the work.

Pyrometer installations on boiler breechings only have made it possible to show an increase of boiler efficiency of from 1 to 5 per cent. The engineering experts of a large industrial concern that has thermocouples (about 40 in all) located permanently in the breechings of all of its boilers and in the economizers, claim an increase from 70 to 77 per cent. in efficiency since the installation of the pyrometer equipment. The firemen are able to ascertain the condition of the fires or boilers at any time, and the writer has found that they watch the pyrometers as closely as they do the steam gages.

Firing when the engine began to lag was the old way; then the steam gage came into use, and the firing was done before the engine lagged. Now when the pyrometer is used the firing is done before the gage lags.

Shaft Fan Signal

The not uncommon mistake made by the headman at a colliery shaft is to allow the fans upon which the cage rests while at a level to remain in an "out" position, so that when the cage descends it, as well as the fans, is damaged.

In order to avoid such an occurrence, an arrangement has been placed in operation at the No. 2 shaft of the Susquehanna Coal Co., Nanticoke, Penn., by which the engineer is signaled when the fans are in an "in" or "out" position. The signal consists of a white painted disk and is located in the engine room directly in front of the engineer.

The fans are operated by a lever at the shaft opening by the headman. This lever is secured to a shaft upon which a crossarm is attached, and which is connected by means of small rods to a second crossarm mounted upon a shaft at any convenient height. On this second shaft, a second crossarm is arranged as shown in the illustration, and is connected by means of two wires to another shaft and crossarm in the engine room, upon which is mounted a white disk signal.

When the fans are in an "out" position with the hoist resting upon them, the disk will show white in the engine room. As soon as the lever is pulled, which brings the fans up against the side of the shaft, the car is free to descend and the disk signal makes one-quarter of a turn so that only its thickness is visible to the engineer. Since this signal has been in operation, there has been no accident due to the hoist striking the fans when in an "out" position. In this instance, the signal is operated from the ground level, the coal cars being hoisted up to the header, nothing but rock, men, etc., being handled at the surface head.

Calculating the Sizes of Feed Pumps

By Victor C. Vance

The size of a boiler-feed pump is calculated to supply a typical boiler installation. Low piston speeds are recommended.

Questions in regard to calculating the feed-pump capacity of a given boiler installation are often asked in engineering examinations and the form in which they are usually framed is about as follows: "Assume a boiler plant consisting of two 72-inch by 16-foot horizontal return-tubular boilers; what size of feed pump would be required to supply this battery?"

The amount of the water that would be required is not stated; hence it is necessary first to estimate this. The evaporation within the boilers may range from nothing to the maximum capacity; therefore, in order that there may be no shortage of water under any conditions of service the pump capacity must be great enough to supply the maximum demand continuously.

The first step toward the solution of the problem is to find the maximum evaporative capacity of the boilers and when this has been done, ascertain what the pump size must be to maintain the water level at this rate of evaporation. The evaporative capacity of the boilers may be found by multiplying the area of the boiler-heating surface, in square feet, by the number of pounds of water evaporated per square foot per hour. No data other than the diameter and the length of the boilers are given with the question. Therefore, it will be assumed that standard conditions prevail. From a table of standard boiler dimensions it will be found that the heating surface of a 72-inch by 16-foot boiler with 3-inch tubes is very close to 1800 square feet. For the two boilers, then, the total heating surface would be 3600 square feet.

In average practice an evaporation of 3 to 8 pounds of water per square foot of heating surface per hour is obtained. Basing the estimates upon an evaporation rate of 5 pounds per square foot of heating surface per hour will allow for a considerable degree of forced draft. At this rate, then, the total evaporation of the boilers would be

$$3600 \times 5 = 18{,}000 \text{ pounds}$$

of water per hour. As a gallon of water weighs very nearly 8⅓ pounds, this evaporation expressed in gallons will be

$$\frac{18{,}000}{8\frac{1}{3}} = 2160 \text{ gallons}$$

per hour.

The size of pump required for delivering this quantity of water might readily be found by referring to a pump catalog, which usually contains tables of pump sizes and capacities. One of these tables is herewith reproduced.

Manufacturers are prone to rate the pumps higher than they should be worked in continuous service; hence it is well to check the catalog figures. For the purpose of facilitating the calculations it will be well to reduce the evaporative capacity of boilers to cubic inches, as the pump dimensions will all be derived in inches.

A standard United States gallon contains 231 cubic inches, so that the evaporation of 2160 gallons per hour reduces to

$$2160 \times 231 = 498{,}960 \text{ cubic inches}$$

For continuous service the speed of the water piston should seldom be more than 25 feet per minute, or 1500 feet per hour. This is equivalent to a piston speed of 18,000 inches per hour. The distance traversed by the piston multiplied by its area will be the total volume displaced by it, and this must be equal to the quantity of water to be pumped, plus an allowance for slip and leakage.

Slip in a reciprocating pump is a loss arising from the reflowing of a portion of the water through the valves before they have had time to seat when the piston reverses its motion at the end of the stroke. In a centrifugal pump the slip is the difference between the velocity of the impeller and that of the water. Slip varies from 75 per cent. of the volume in small centrifugal pumps to as low as 5 or 6 per cent. in high-grade waterworks pumps. In the ordinary boiler-feed pump the usual allowance is about 20 per cent. to cover this loss. Therefore, if the actual amount of water that must be pumped per hour is, as figured in the present case, 498,960 cubic inches, the water-piston displacement per hour must be

$$\frac{498{,}960 \times 100}{80} = 623{,}700 \text{ cubic inches}$$

The piston travels 18,000 inches per hour; therefore, in order that its volumetric displacement per hour may be 623,700 cubic inches, its area in square inches must be

$$\frac{623{,}700}{18{,}000} = 34.65 \text{ square inches}$$

The area is equal to the square of the diameter multiplied by 0.7854. Then, letting d represent the diameter of the water piston

$$0.7854 \times d^2 = 34.65$$

or

$$d = \sqrt{\frac{34.65}{0.7854}} = 6\tfrac{2}{3} \text{ inches}$$

That is, a 7-inch plunger would be required if the pump were of the single-cylinder double-acting type. More probably, however, for boiler-feed purposes a pump of the duplex double-acting type would be selected. The calculated piston area then of 34.65 square inches would be divided between two plungers, or pistons, each having 17.325 square inches.

The diameters of these plungers are found by the same method as used in connection with the single-cylinder pump. This gives for the diameters of the duplex plungers

$$\sqrt{\frac{17.325}{0.7854}} = 4.7 \text{ inches}$$

or, say, 4¾ inches.

Having found the plunger diameters for both the single cylinder and the duplex types of pumps, the next step is to fix upon the length of stroke. The length of stroke multiplied by the number of strokes gives the average plunger speed. The plunger speed has been established already at 18,000 inches per hour, so that it now remains merely to so proportion the length of stroke and the number of strokes that their product will be equal to this speed.

On account of the changing and seating of the valves at the end of each stroke, the more time that is taken in

CAPACITY IN GALLONS PER HOUR AT 60 DOUBLE STROKES PER MINUTE

Single cylinder, no slip or leakage allowance

Diameter of Plunger, Inches	Stroke, Inches								
	2	3	4	5	6	7	8	9	10
2	195	293	391	489	606	684	780	880	978
2½	300	458	610	763	900	1,208	1,220	1,374	1,500
3	440	660	880	1,100	1,320	1,500	1,760	1,980	2,202
3½	600	900	1,200	1,500	1,800	2,100	2,400	2,700	3,000
4	780	1,200	1,572	1,956	2,340	2,748	3,132	3,534	3,900
4½	1,000	1,500	1,980	2,478	2,960	3,468	3,960	4,464	4,950
5	1,320	1,800	2,440	3,054	3,660	4,260	4,890	5,496	6,100
6	1,800	2,640	3,528	4,400	5,280	6,180	7,056	7,938	8,808
7	2,300	3,600	4,788	6,000	7,200	8,400	9,600	10,800	12,000
8	3,120	4,700	6,260	7,800	9,400	10,980	12,528	14,040	15,696
9	3,960	5,940	7,932	9,900	11,904	14,220	15,840	17,820	19,800
10	4,890	7,320	9,280	12,240	14,688	17,160	19,560	22,020	24,500

reversing the direction of motion of the plunger, the quieter and more efficient the pump action will be. Practice has shown a diversity of opinion in this respect, but 20 double strokes per minute will not be far out of the way for satisfactory service and the vibration and wear and tear on pumps, valves, piping, etc., will be sufficiently reduced to more than offset the saving in first cost that might be effected by installing a smaller but faster-running pump.

At this rate there would be

$$2 \times 20 \times 60 = 2400$$

single strokes per hour and, as previously stated, the number of strokes per hour multiplied by the length of stroke equals the plunger travel per hour. The latter has been fixed at 18,000 inches and the number of strokes at 2400; hence the length of stroke is

$$\frac{18{,}000}{2400} = 7.5 \text{ inches}$$

Therefore, for the single-cylinder pump the size of the water end would have to be 7x7½ inches in order to pump the required amount of water to the boilers at 40 single strokes per minute.

In the case of the duplex type the total plunger area and the average number of strokes are the same as that of the single-cylinder type; consequently, the length of stroke must be the same in both types. The duplex water end will, therefore, be 4¾ inches in diameter by 7½ inches stroke.

These dimensions, both in the case of the single-cylinder and the duplex types, are fairly well in accordance with standard pump design. By referring to the table previously given it will be found that pumps of these dimensions are rated at much higher capacities than that for which they have been figured in the present case. The single-cylinder pump, according to the table, has a capacity, neglecting slip and leakage, of approximately 9000 gallons per hour, as against the 2160 gallons per hour calculated, while the duplex pump, which is equivalent to two single-cylinder pumps, would, of course, have about the same pumping capacity of 9000 gallons.

It will be noticed, however, that the ratings in the table are based on a much higher speed of operation and the writer believes, from long years of practical experience in the operation of various types of pumps, that better service in the long run will be obtained by operating them at speeds not much, if any, in excess of what has been used in the foregoing calculations.

The steam end of a pump must, of course, drive the water end, but in boiler feeding the same pressure per unit area acts on both water and steam pistons. Therefore, it is necessary to make the latter the larger in order to get sufficient total pressure to drive the former. The difference in the sizes of the two is usually fixed somewhat empirically according to the work required of the pump, but in order that the pump may be serviceable under a wide range of conditions, the steam piston is usually made much larger than might be necessary for merely overcoming the resistance of the water plunger. Then any excess of speed that may tend to develop, where the work is not sufficient to hold it down, is prevented by throttling the steam supply at the throttle valve. The ratio of the diameter of the steam piston to that of the water piston is often fixed at about 1.4 to 1.

To sum up then, for one single-cylinder pump, taking the diameters of the steam and water pistons at this ratio, the diameter of the steam piston would be

$$7 \times 1.4 = 9.8 \text{ inches}$$

say, 10 inches; the diameter of the water piston, 7 inches; the length of stroke, 7½ inches; and the number of single strokes per minute, 40. For the duplex type the figures would be, diameter of steam pistons,

$$4\tfrac{3}{4} \times 1.4 = 6.65 \text{ inches}$$

say, 6¾ inches; diameter of water pistons, 4¾ inches; length of stroke, 7½ inches; number of single strokes, each side, 40 per minute.

How a Cracked Cylinder was Repaired

At the No. 2 shaft of the Susquehanna Coal Co., Nanticoke, Penn., can be found a large hoisting engine on which an interesting repair job has been made. The cylinders are 28x32 in., and each is fitted with a main steam chest, from which the steam is supplied to both ends of the cylinder through a steam passage cast on one side of the cylinder.

The outer casing of the steam passage leading to the head-end port on one cylinder cracked for a distance of about 12 in., which not only leaked steam, but rendered the cylinder dangerous to operate. The hoisting engine is in constant use, and when that stops, the output of the mine also stops. Hence it was necessary to make repairs as quickly as possible, which was done in the following manner:

Four 1¼-in. studs were screwed into the frame of the engine on both sides, as shown on the accompanying illustrations. On the side of the cylinder on which the crack occurred, Fig. 1, four straps of wrought iron, each 3½ in. wide and ⅝ in. thick, were fitted with bosses which were bolted to the strap by five ¾-in. bolts. Each boss was drilled for an eye-bolt to which was attached a ½-in. chain. The other end of each chain was secured to an angle iron which was bolted to the framework on the opposite side of the cylinder, Fig. 2. The lagging and asbestos covering were then removed from the cylinder, the chains and eye-bolts were put in place through the

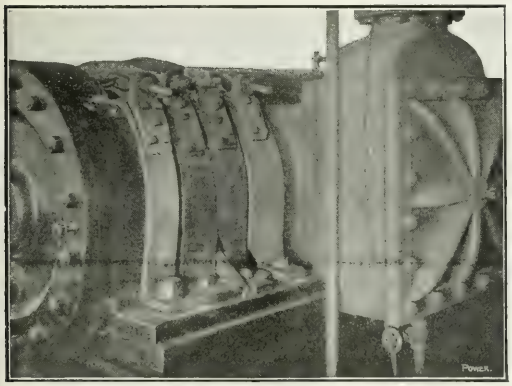


FIG. 1. STRAPS AND BOSSES BOLTED TO ENGINE FRAME

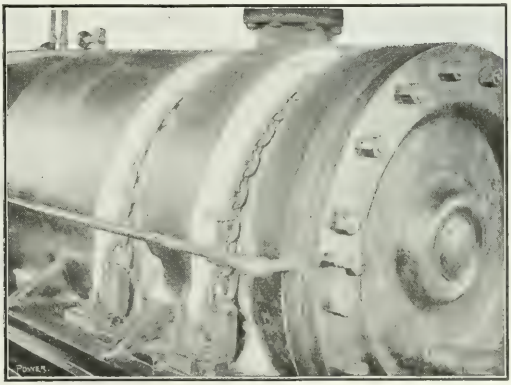


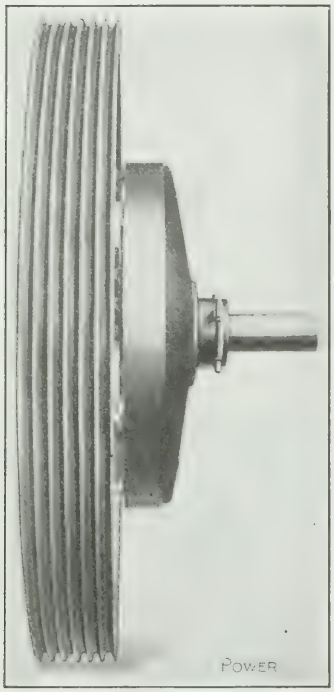
FIG. 2. ANGLE IRONS WITH ATTACHED CHAINS BOLTED TO ENGINE FRAME

holes in the iron bands and were screwed up tight by bolts, as shown in Fig. 1.

This prevents the crack from extending a greater distance and practically stops all leakage of steam.

The Ewart Clutch Guard

This metallic guard, shown herewith, incloses the clutch mechanism and protects the operator against accidental contact with it.



EWART CLUTCH GUARD

It is manufactured by the Link-Belt Co., Chicago, Ill., for applying to its line of clutches.

Penberthy Globe Valve

The accompanying illustrations show sectional views of a new line of valves manufactured by the Penberthy Injector Co., Detroit, Mich.

Fig. 1 shows a regrinding globe valve. For the body a form intermediate between the sphere of the original globe valve and the flattened shape adopted by some makers has been chosen after study and experiment to determine the form of passage which would offer the least resistance to the passage of the fluid. The bonnet fits to the valve body with a ground joint, and is held in place by a locknut which bears against a machined surface on the upper side of the bonnet.

The valve can be reground by unscrewing the locknut, placing a pin through the disk holder and the stem and screwing in the valve stem until the disk bears against the seat. The valve stem and disk are then turned until the true surface is obtained. The pin is afterward removed so that the disk can turn and seat in a new position each time the valve is closed. The valve-stem packing is held in by a gland and nut.

In Fig. 2 is shown a removable valve disk. It is held in place by a threaded

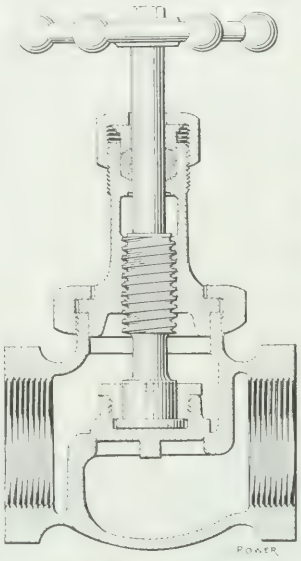


FIG. 1. REGRINDING VALVE

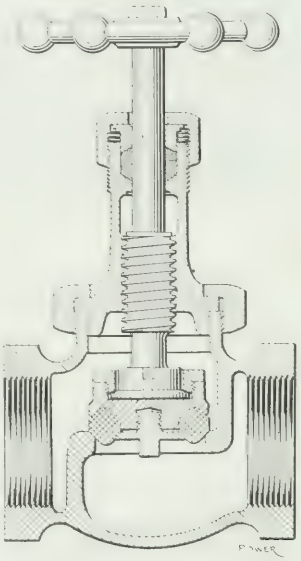


FIG. 2. RENEWABLE DISK VALVE

washer. Should one side of the disk become cut or worn, it can be reversed or renewed when both surfaces have become injured.

Goulds Single and Doubl Acting Triplex Pump

A double- and single-acting piston pump, made for pressures up to 150 lb. and in capacities ranging from 25,680 to 57,600 gal. per hour, is shown in Figs.

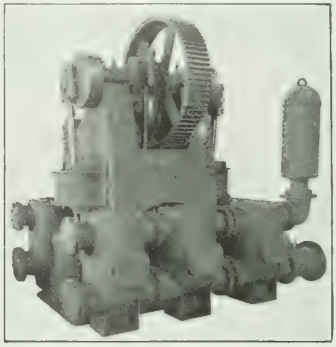


FIG. 1. DOUBLE ACTING TRIPLEX PISTON PUMP

1 and 2. They are for general water services requiring large capacities at moderate pressures.

The new feature of these pumps is that the two sets of gears have been replaced by a single gear and pinion. This gear is located between the two heavy standards of the frame. The pinion

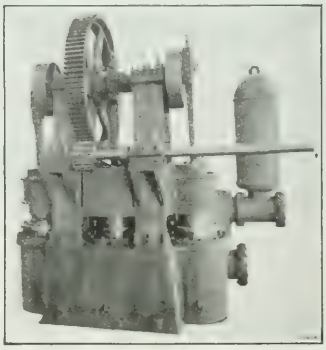


FIG. 2. SINGLE ACTING TRIPLEX PISTON PUMP

shaft is extended beyond the frame for a pulley or for direct connection to an electric motor or other driver. The construction has been made such as to give easy access to the cylinders. These pumps can be supplied with bronze plungers, cylinder linings, glands, etc.

These pumps are manufactured by the Goulds Mfg. Co., 56 West Fall St., Seneca Falls, N. Y.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

Inclosed Flame-arc Lamps

1244. *Are flame-arc lamps built in the inclosed form?*

Yes. Most of the flame-arcs now installed are of the inclosed type.

1245. *Is the inclosed type like the open type?*

No. The carbons are arranged in line with each other, like those of the ordinary carbon arc lamp, and the mechanisms are very similar to those of the ordinary kind.

1246. *What kind of carbons are used in the flame-arc lamp?*

"Mineralized" carbons; that is, rods which consist either of a mixture of carbon and certain light-giving salts, or which are made of pure carbon with a hole through the center, this hole being filled with a mixture of carbon and salts.

1247. *What effect do the salts have upon the light?*

They produce a much greater intensity of light than carbon alone and also counteract the tendency to give a bluish or violet light, which inclosed carbons have. The light is a brilliant golden yellow.

The Metallic Flame-arc Lamp

1248. *Are there any other forms of arc lamp?*

Yes; the metallic flame-arc lamp, one of the common forms of which is shown in Fig. 412. This is the most efficient arc lamp so far produced.

1249. *What voltage is required by the metallic flame-arc lamp?*

Across the terminals, about 68 volts.

1250. *Describe the principal features of this lamp.*

The lamp takes its name from the metallic electrodes used in place of the carbon rods of other lamps. Referring to Fig. 412, it will be evident that the lower electrode is in the form of a button or plug; this is made of copper and is the positive electrode. The upper electrode is a pencil composed of metallic oxide called "magnetite" and is the negative electrode of the lamp. It is fed downward by a mechanism as it wastes away somewhat as in the case of the ordinary carbon lamp. The positive button is not consumed; hence it is not necessary to use the rod form.

1251. *Describe the functions of the mechanism shown in Fig. 412.*

A diagram of this mechanism and the lamp circuits is shown in Fig. 413. When the circuit to the lamp is closed, the current passes from the terminal *P* through the resistor *R*, feed magnet and contacts *J* and *I* to the negative terminal *N*. This energizes the feeding magnet, which pulls its cores *EE* downward and thereby lowers the negative rod into contact with the positive button. This contact shunts most of the current out of the feeding magnet, the current passing to the positive button directly through the series cutout magnet, which lifts its armature *I* and opens the circuit through the feeding magnet. The spring above the feeding magnet then pulls the cores *EE* up again, separating the electrodes and striking the arc.

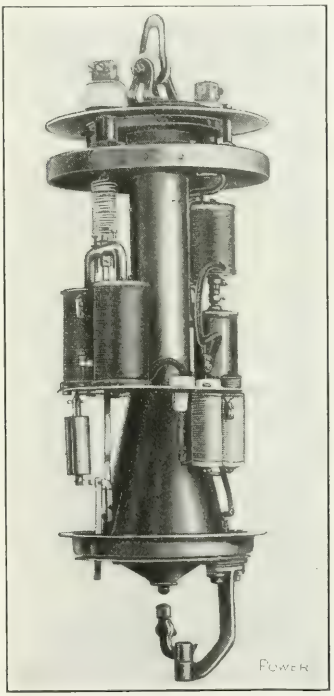


Fig. 412. Working Parts of Lamp

1252. *How does the mechanism control the length of the arc as the rod burns away?*

The shunt cutout magnet *K* is connected across the arc, and when the arc lengthens, due to the burning away of the rod electrode, this magnet becomes strong enough to lift its plunger core with the contact *J* until the latter touches the contact *I*, which was previously lifted by the series cutout magnet. This restores the circuit through the feeding magnet, which pulls the electrodes into contact again, and is again cut out of circuit as just described, allowing the spring to strike the arc again.

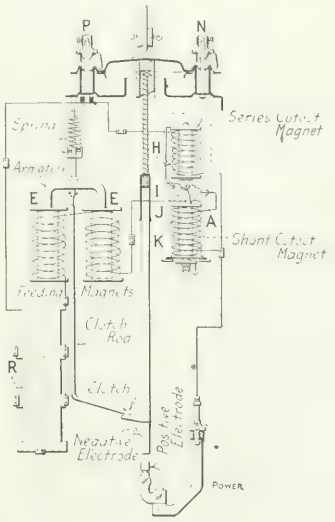


Fig. 413. Diagram of Mechanism and Circuits

1253. *Then the arc is put out when it becomes too long, and a new one established?*

Yes; the rod electrode does not "float" under the control of the feed magnet as in the carbon arc lamp. The spring pulls the armature up against a stop which is set for the correct length of arc.

1254. *What is the reason for placing the negative electrode above the positive?*

There are two advantages; the greater portion of the light comes from the flame of volatilized oxide from the negative electrode, and the length of the negative electrode is not limited except by the height of the lamp. This permits the use of an electrode having a long burning life. The latest forms of magnetite or metallic arc lamp, however, are

made with the positive electrode above and the negative rod below.

1255. *Can this type of lamp be operated on alternating current?*

No. Since the positive electrode must be copper and the negative electrode metallic oxide, the current must always pass through the lamp in the same direction. Direct current must therefore be used.

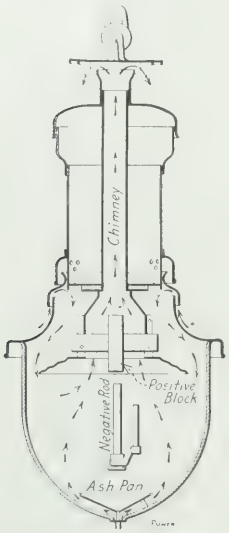


FIG. 414. SHOWING AIR CIRCULATION

1256. *Is the negative rod consumed by the current?*

Not entirely; there is some ash and whatever is not carried out of the chimney of the lamp by the strong air circulation is deposited in a little pan below the lower electrode. Fig. 414 will make these references clear.

1257. *Does the lamp operate with constant potential or constant current?*

The mechanism just described operates only with constant current, but other mechanisms are made for operation on constant-potential circuits.

1258. *How is constant direct-current obtained?*

Either from a constant-current direct-current dynamo or from what is known as a mercury rectifier, supplied from an alternating-current circuit. The constant-current dynamo was formerly the only available source of such current, but since the development of the mercury rectifier the constant-current machine has become practically obsolete.

THE MERCURY RECTIFIER

1259. *What is the mercury rectifier outfit for converting alternating current into a constant direct current?*

The mercury rectifier outfit consists of a constant-current regulating transformer, a mercury bulb and a small starting transformer, connected up as shown in Fig. 415 and mounted on a panel containing the necessary switches, instruments, etc., for operating it.

1260. *Explain the connections shown in Fig. 415.*

The two secondary coils of the regulating transformer are connected in series, and their free ends are connected to the upper electrodes of the rectifier bulb, which are called "anodes." The two leads from the lower terminals of the rectifier, which are "cathodes," are connected to the secondary terminals of a small starting transformer, the primary of which is supplied from a small auxiliary secondary coil on the regulating transformer. The positive lead to the direct-current circuit is brought out from the middle of the starting transformer secondary winding. The negative direct-current lead is brought out from the connection between the two main secondary coils of the regulating transformer.

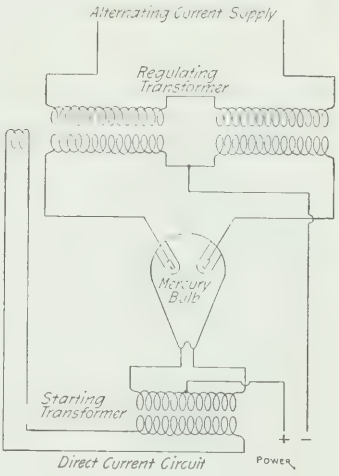


FIG. 415. CONNECTIONS FOR MERCURY RECTIFIER

1261. *Describe the operation of the rectifier outfit.*

The bulb is tilted so that the mercury in the two lower electrode pockets bridges the space between them, thereby short-circuiting the starting transformer secondary, which is connected to these lower electrodes, or cathodes. When the bulb is returned to the vertical position, the breaking of the mercury bridge between the cathodes produces a spark which breaks down the resistance at the surface of the cathodes and vaporizes the mercury, from which current passes freely from the mercury to the upper electrodes, or anodes, which are of graphite. The alternating electromotive forces from the regulating transformer, which are alternately impressed upon the two graphite anodes of the rectifier, cannot pass from one of the graphite electrodes to the other, because the current cannot flow from mercury vapor into a solid electrode, although it flows easily from a solid electrode to the mercury vapor. Each impulse, however, passes down from one anode through the vapor to one or both of the mercury cathodes, from which they all emerge in the same direction, resolving into a direct current slightly pulsating in character.

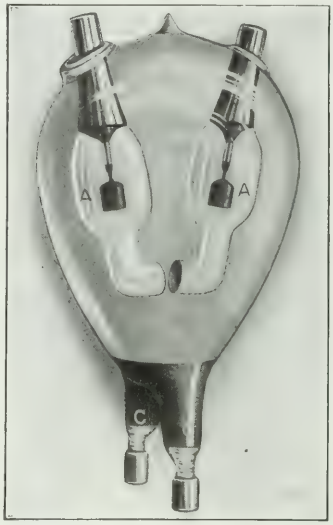


FIG. 416. MERCURY RECTIFIER BULB

1262. *Illustrate and describe the mercury rectifier bulb in detail.*

The mercury rectifier bulb is shown separately in Fig. 416. It consists of a pear-shaped glass bulb about 7 in. in diameter at its largest part, provided with four electrodes. The two upper electrodes, or anodes, *A* and *A*, are graphite blocks and they are mounted within glass tubes which serve to direct the course of the current from the anodes to a point over the two cathodes, *C* and *C*, which are little pools of mercury. The leading-out wires from the graphite anodes pass through heavy glass plugs which serve to prevent flashing across in case conditions should accidentally arise to provoke that. The glass bulb is exhausted of air, like that of an incandescent lamp, to prevent oxidation of the mercury and graphite.

A prize of which the amount shall be the accrued interest at 3 per cent. upon 150,000 francs donated for the purpose by George Montefiore Levi will be awarded in 1914 for the best original work presented on scientific advance-

ment and progress in the technical application of electricity. The jury will consist of ten electrical engineers, five of whom must be Belgian, under the presidency of the professeur-directeur of the Institut Electrotechnique Montefiore. The conditions and particulars of the competition may be obtained by addressing G. L. Hoest, secretary-general, 31 rue St. Gilles, Liége, Belgium.

LETTERS

Some Experiences in a Small Electric Plant

The article by E. M. Graham in the issue of Apr. 9 reminded me of the difficulties that were experienced by some young men in trying to make a success of an electric-lighting business in a town of about 3500 inhabitants.

The first attempt in the electric-lighting line was made by the town authorities, who constructed a street-lighting system and contracted with the electric company of a neighboring town to supply the current. This arrangement became very unsatisfactory after a time, particularly as the company supplied the system from a water-power plant which frequently failed to give service in dry weather.

As the outlook seemed good for working up a lighting business, three young men who were constructing a small manufacturing plant in which they expected to use electric current thought that they might gain something by operating the plant at night to light the town. With this in view a single-phase alternator was purchased to be driven by a high-speed engine and a return-tubular boiler was to supply the steam.

The attention required by the electric end of the business soon left all other departments far behind. The contract was purchased from the other lighting company and the work of putting up commercial lines proceeded quite rapidly. After the plant was in operation, troubles began to multiply and the young men failed to realize that the business was not large enough to allow them to hire all of their work done and that they should expect to do most of it themselves until the business was large enough to justify more help. They hired two men to operate the plant, which ran only during the hours when lights were necessary, and a man to look after the lines and do the inside wiring. They sometimes had still another man.

After about a year of operation the engine began to give trouble and it continued to give more, until it finally wrecked itself so badly that it was necessary to buy a second-hand engine from another company and haul it overland and install it on the foundation of the first one. Of course, the bolts did not fit, and two hard pine timbers were first bolted down and the engine was bolted to them, then the lights were put on again after two nights of darkness.

The older engine was repaired and preparations were made to put it back on its foundation, make a new one for the second one, buy a new generator, so as to have a duplicate plant. Before these plans could be more than thought of a careless engineer, after keying up, left the setscrew loose which held the key in the crankpin box, and it came out soon after starting up for the night. This caused the engine to lose a cylinder head, a pair of guides and a crosshead and to injure various other parts. Then this engine was pulled off the makeshift foundation and the first one put back on to take up the labor as before. During the next six months the town had to do without lights only one night.

The other engine was repaired, put on a new foundation, and all arrangements were made to put in another generator, but the firm was not able to buy it and had to worry alone as before.

It can easily be imagined what the lighting service furnished by this plant would be; it was the laughing stock for the whole town and there seemed to be no hope of improvement for there was no way to procure the extra apparatus to bring about better service. The help had to wait long periods for their wages, which did not make them very loyal or as interested as they might have been. Yet all this might have been prevented if the owners of the business had not tried to live too high and had let the plant take a fair share of its income for repairs and improvements.

That this was a fine opportunity for a central-station man as we understand the term today will not be denied and as a large electric company was buying all of the small suburban companies this one was obliged to sell out to it or see an opposition system set up which would be immediately patronized by all those who wanted electric service.

G. H. Kimball.

East Dedham, Mass.

Synchronizing with Lamps

Referring to the inquiry by "M. H. J." in the Apr. 9 issue as to the use of lamps for synchronizing, I wish to point out the advisability of using a voltmeter in addition to the lamps. When lamps are used alone, the indication of actual synchronism is not possible because the eye cannot distinguish small differences in brilliancy when synchronizing "bright," and the filaments will not show any color until there is a serious difference of potential, when synchronizing "dark."

If a synchronism indicator is not provided, a voltmeter should be included in the arrangement and connected across the lamps in one of the phases. When the voltmeter reads zero and the lamps are dark, the switch should be closed.

If lamps were used alone, in synchronizing "dark," a broken filament would cause trouble, as stated in the answer to "M. H. J.," and it would cause at least an objectionable delay in synchronizing "bright."

F. P. Joseph.

Baton Rouge, La.

[The only reliable method of synchronizing is by means of a synchronoscope, which indicates differences of phase positively and quantitatively.—Editor.]

Burnt Commutator Bars

I have a 25-kw. compound-wound generator of 117 volts, with a two-path armature winding. There are two commutator segments side by side that show a discoloration as if burnt; some days it appears regularly, and sometimes not for a day or two, occasionally skipping four or five days.

The discoloration begins on the outside end and extends along the two segments about an inch. Very little rubbing with fine sandpaper is sufficient to clear the discoloration and make the bars bright again.

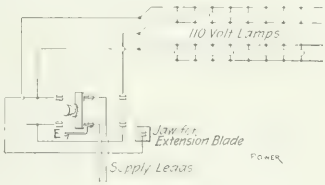
The mica strips do not stand above the bars and are not loose or broken away at any point. Who can tell me what causes the apparent burning?

George Kramer.

Brooklyn, N. Y.

A Lighting Circuit for Either 220 or 110 Volts

It was necessary to wire a building for lights in such a manner that either 220 or 110 volts could be used without changing the lamps. Only one pair of power leads came into the building, so that only one voltage was available at



Mr. Forbing's Connections

one time. When current supply of one voltage was not available, current of the other voltage was.

In order to meet the requirement described, a double-throw double-pole knife switch with an extension finger on one blade was installed and connected up as shown by the accompanying diagram. Closing the switch to the left connected the lamp circuits in two series groups for the 220-volt supply and closing it to the right put them in parallel for 110-volt supply.

F. J. Forbing.

Ft. Casey, Wash.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Extensive Use of Coke-Oven Gas*

By C. A. Tupper

The use of coke-oven gas in internal-combustion engines has rapidly developed until now a great number of large plants of this kind are in successful operation. While the majority of these plants are to be found in Germany, there are many opportunities for similar development in this country. The accompanying illustrations will serve to give an idea of the extent to which such gas power is being utilized abroad. Fig. 1 shows the interior of the electric generating station of the Eschweiler Bergwerks Verein, at Alsdorf, Germany, which is said to be the largest power station in the world, operated on coke-oven gas. It is equipped with engines built by the Maschinenfabrik Augsburg-Nürnberg, direct-coupled to alternating-current generators from the shops of the Allgemeine Elektricitäts Gesellschaft, at Berlin. There are nine of these units at present installed, with an aggregate rated capacity of 15,000 hp., and provision is being made for others. The gas used here is supplied from several batteries of Koppers regenerative coke ovens, partially illustrated in Fig. 2, in connection with which there is operated a byproduct plant for the recovery of ammonium sulphate, tar compounds, etc.

Originally, the gas from the coke ovens in use here, was burned under boilers, and the steam thus produced was consumed in a number of isolated engine plants installed, wherever necessary, over the wide area of the company's operations. For these comparatively small power stations, the total running expense and cost of upkeep were relatively high, particularly as it was necessary to carry a spare engine in each locality.

Gas-engine Driven Electric Plant

The obvious remedy for such conditions lay in the construction of a central electric-generating station and the complete electrification of all the company's plants. When it came, however, to deciding upon the type of prime mover to be installed, the verdict was in favor of gas engines, rather than the continued use of steam, for the reason that, with a steam plant of even the most efficient type ordinarily used, it is only possible to convert into power a much smaller percentage of the calorific value of the gas than can be utilized with gas engines. The manage-

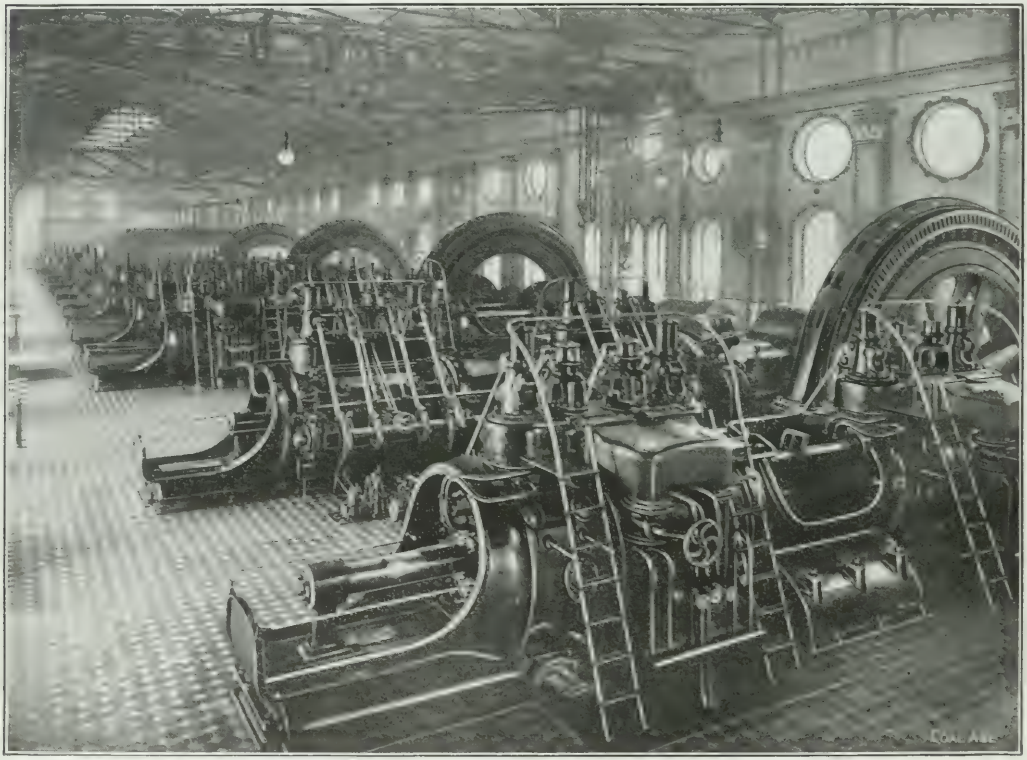


Fig. 1. Power Plant Using Coke-oven Gas, Eschweiler Bergwerke Verein

*Reprinted from "Coal Age."

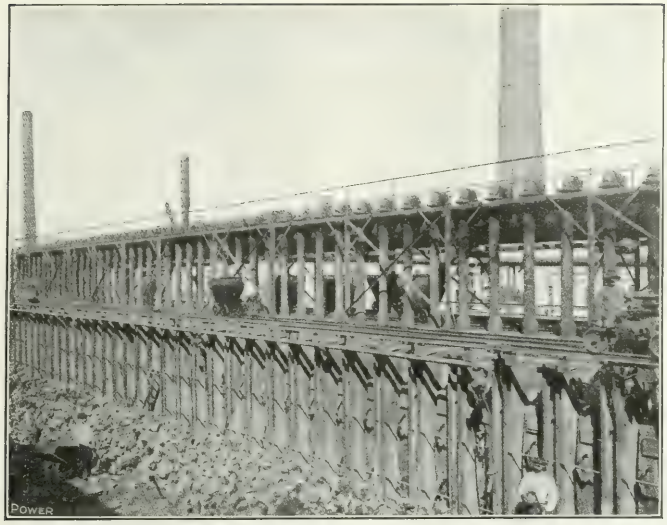


FIG. 2. KOPPERS COKE OVENS WITH BYPRODUCT PLANT IN BACKGROUND

work shelves, fans being used for forcing the gas through the filter frames, and the tar extractors, originally used, have been eliminated. After the Koppers-type ovens had been substituted for an older type, these extractors were found unnecessary, as the byproduct plant effectually removed all tar. A central chamber also has been provided, where, as the ore becomes saturated, it can be dumped from the frames and regenerated by exposure to the air. The two sides of the filter are operated alternately, so as to afford opportunity for this freshening process, and thus the same ore can be used for a considerable length of time.

The gas, as cleaned, has a composition approximately as follows:

		Per cent.
Carbon dioxide	CO_2	2.00
Oxygen	O	0.82
Carbon monoxide	CO	5.82
Methane	CH_4	20.83
Other hydrocarbons	$CnHm$	1.40
Hydrogen	H_2	55.11
Nitrogen	N	14.02
		100.00

From the filter plant, the gas can be sent directly to the gas engines or to one of two gas holders, having a combined capacity of 52,500 cu.ft., from each of which two separate lines, with drain-off valves, etc., lead to the power station. Ordinarily the gas passes through these holders. To insure a sufficient supply of gas when the number of ovens in service is not equal to the demand, gas producers have been installed as auxiliaries. The present output of power represents about twice the amount, proportionately, that was formerly obtainable from the same number of ovens when steam engines were used.

ment therefore decided to dispose of the steam engines, one after another, and gradually concentrate the production of power in a gas-engine-driven electric plant.

The gas being used under the boilers at that time would not, however, do for use in gas engines; and the next problem was to secure a product sufficiently free from impurities to serve this latter purpose. The installation of a byproduct recovery plant was determined upon at the same time, and this provided for the removal of tar compounds, as well as some other deleterious substances; but the necessity remained for extracting the large percentage of sulphur present, and to provide for the effective removal of this, a special cleaning plant was constructed. This consists primarily of layers of bog iron laid out on rough wooden lattice-

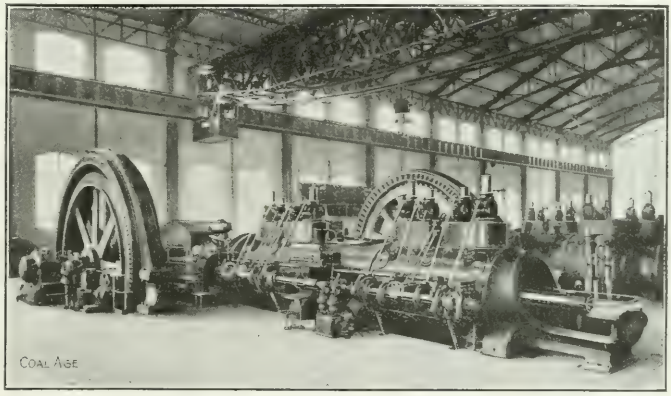


FIG. 3. GAS-POWER PLANT, AT NANCY, FRANCE

FIG. 4. KOPPERS BYPRODUCT PLANT, AT OESPEL

COMBINED GAS-ENGINE AND STEAM-TURBINE SYSTEM

Without going further into the details of this station, the gas-power plant of the Royal Prussian Mines for the Saar-

brücken district, at Heinitz, Germany will next be considered. This contains seven engines, totaling 10,000 hp. and two more, which are to be put in operation before long, will increase the total to 16,000 hp. All the gas here used is supplied from Koppers ovens, similar to those shown in Fig. 2, first passing through a byproduct plant and gas holders of 210,000 cu. ft. capacity. There are no producers held in reserve, but a steam-turbine plant at the other end of the district is connected with this station by transmission lines and is operated in parallel with it, supplying whatever excess power is needed.

The gas, as it leaves the byproduct plant, is cleaned in a dry filter and its average composition may be given as follows:

		Per cent.
Carbon dioxide	CO_2	2.87
Oxygen	O_2	0.98
Carbon monoxide	CO	7.46
Methane	CH_4	26.78
Other hydrocarbons	CnHm	3.70
Hydrogen	H_2	48.20
Nitrogen	N	10.01
		100.00

It will be noted, in both the cases cited, that the gas from coke ovens is not unlike natural gas, although lower in methane. At Alsdorf it runs from 340 to 450 B.t.u. per cu.ft., and at Heinitz from 470 to 540 B.t.u. The producer gas generated in the auxiliary plant of the Eschweiler Bergswerk Verein, at Alsdorf, averages only 113 B.t.u.; so it will be seen that the coke ovens furnish a comparatively rich gas.

The situation in the Saarbrücken district is similar to that at Alsdorf, but the field is vastly more extensive, as the distribution system serves 27 mines and aggregates more than 70 miles in main cables, with a network of feeder lines. This is all linked together on the "ring" plan, and any point can be supplied from either the gas-engine plant or the steam auxiliary station at the other end of the district. Originally, each mine or group of mines was served by its own steam-engine plant.

In Fig. 3 is shown the 4000-hp. power station of the Societe Anonyme des Hauts-Fourneaux, Pompey, near Nancy, France, which is practically identical in appearance and in the design of the electric units with the 3000-hp. plant of the Rheinpreussen Colliery, Homberg, Germany, operating on coke-oven gas.

Fig. 4 illustrates one of three Nürnberg gas engines, aggregating 6000 hp., running on coke-oven gas in the power plant of the Powell Duffryn Steam Coal Co., Ltd., at Bargoed near Cardiff, Wales, and a similar plant of the same capacity, but with direct-current generators, is operated by the Luxemburger Bergwerks & Saarbrückner Eisenhütten A. G. at Burbach, near Saarbrücken, Germany, on a combination of blast-furnace and coke-oven gas.

Power Equivalent of Coke-oven Gases

Taking the gas-power station at Heinitz as fairly representative of advanced German practice in the utilization of coke-oven gas, it may be said that 120 ovens now in service there, with the long coking period of 41 hours and a daily production of 6.7 tons of coke per oven, yield surplus gas to the quantity of 3,600,000 cu.ft. during each 24 hours. This is found, in actual operation as utilized in gas engines driving alternating-current generators, to be equivalent in electric power to about 100,000 kw.-hr., or 120 kw.-hr. per ton.

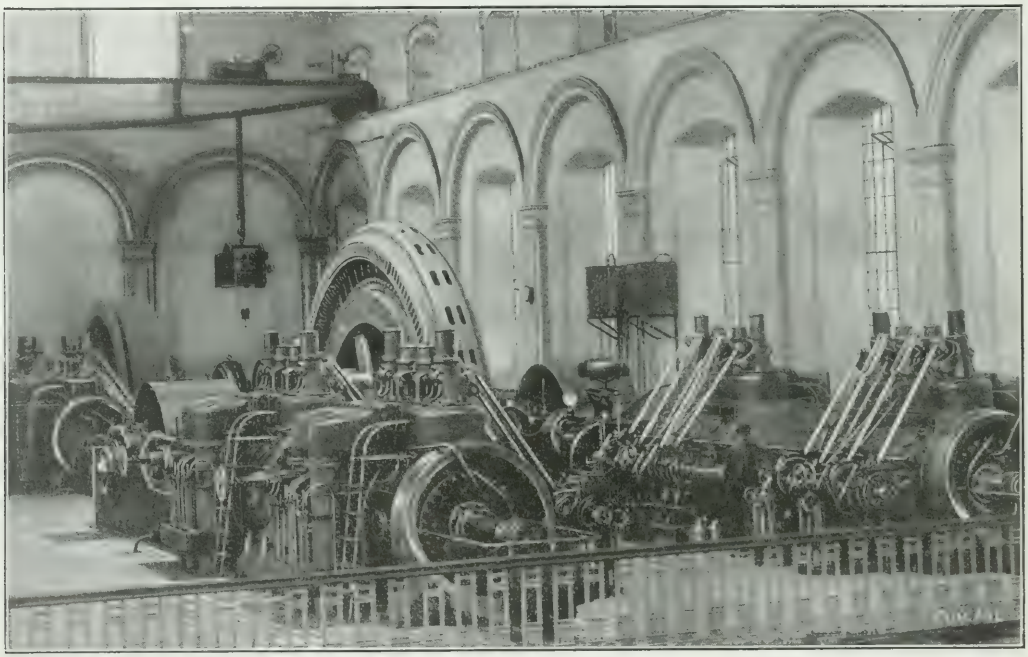


Fig. 5. Gas-power Plant at Bargoed, Wales

Comparing this with the installation of 560 Koppers ovens made for the Steel Corporation at Gary, Ind., with a coking time of 16 to 18 hours and a yield of surplus gas amounting to about 45,000,000 cu.ft., some idea can be obtained of the enormous power possibilities of the latest byproduct system. By "surplus" gas is meant the quantity available after heating the regenerative ovens, which requires from 50 to 65 per cent. of the whole, and after deductions are made for other minor purposes. Taking as a basis the figures compiled by German engineers, prior to the recent increase in coking capacity, it is apparent that upward of 2,800,000 kilowatt-hours of electric energy would be available each day of the year, if all the coke consumed were

to be produced in modern byproduct ovens. Even this does not allow for reduced coking periods and refinements of practice such as have been introduced at Joliet, Gary, Birmingham and elsewhere in this country. However, it might not be economical to convert all this energy into electric power, as there is usually a good market for much of the gas for illumination and heating in cities and towns; but the surplus for utilization in internal-combustion engines would still be large.

Where the gas is to be used in gas engines, the byproduct plant is a necessity; for otherwise the matter carried in suspension and chemically combined with the gas cannot be removed without disproportionate expense. In connection with the origin of the byproduct system, it is interesting to note that an Alsatian cokemaker named Stauf, of Saarbrücken, made practical experiments along this line with a battery of ovens, as far back as 1772.

Byproduct Recovery Plants

Since that time, and particularly in recent years, a number of effective systems have been developed; among the best known are the Semet-Solvay, Otto Hoffman, Otto and Koppers. A typical plant for the recovery of byproducts, and consequently the preliminary cleansing of the gas, is described by Prof. Chas. E. Munroe, of George Washington University, in his report to the U. S. Government on coke making. First in importance in such plants, are the exhausters, which remove the gas from the ovens, draw it through the mains and coolers, force it through tar scrubbers, where the tar, which exists in finely divided particles in suspension, is removed through friction, and thence lead it to the ammonia scrubbers. These are followed by the ammonia recovery plant, where weak ammoniacal liquor is converted by distillation into concentrated crude liquor or into ammonium sulphate. The gas itself passes from the ammonia scrubbers to the benzol recovery plant, where benzol is obtained by scrubbing it with dead oil. It is then drawn through the dry filter previously described, for the separation of the remaining sulphur and cyanogen compounds. The details and ramifications of byproducts plants vary widely, because the substances obtainable from crude coke-oven gas are quite numerous. So far as the subject of this article is concerned, however, the main object is to strip the gas of everything carried in suspension which would be deleterious to the cylinders or other parts of gas engines, and deliver it at the final dry filter plant with only such chemical compounds as are there readily removable. Fig. 4 is a view of a Koppers plant at Oespel, Germany, showing the condensers, coolers, tanks, etc.

Additional power from coke ovens can also be obtained by utilization of the waste coke, or coke "riddlings" in a producer especially designed for that purpose. This system will be described in a later article.

As previously mentioned, the gas is customarily passed through holders, in which it is blended, and then drawn by natural suction to the cylinders of the gas engines. The four stroke-cycle, double-acting type of engine has been most successfully used abroad; and for large plants twin-tandem machines, with heavy flywheel rotors in the generators are preferred. Quality, or constant compression, regulation has displaced the quantity regulation originally tried, and with this change there have been removed the principal difficulties which were still encountered after the problem of cleaning the gas had been solved. Trouble with the stuffing boxes, uneven heating of the cylinders, distortion of piston rods, defective ignition systems, etc., which were so discouraging at first and had such a deterrent influence upon similar efforts in this country, have practically been eliminated. Water jacketing and cooling, lubrication, etc., have also been made both effective and economical.

Gas-Producer Investigations of the Bureau of Mines

The forthcoming annual report of the director of the Bureau of Mines in referring to the gas-producer investigations being carried on by that department, says:

"These investigations were undertaken with a view to the possible discovery of more efficient means of utilizing coals without smoke in various government power plants, and especially to the possible discovery of a more efficient means of generating producer gas for use as power on board government ships.

"Accordingly, a small experimental producer of 150 hp. was erected for these investigations. It has been operated at high temperatures for the purpose of determining the possibility of removing the ashes from the producer in the form of a liquid slag, and of improving the quality of gas for power purposes. Coke was the principal fuel used; limestone was added in varying proportions to aid in fluxing the ash and thus making the slag more liquid. It was found that with coke and the proper proportion of limestone the ash can be made to slag readily and to flow freely. The operation of the producer at high temperatures showed also that the quality of the gas is much improved because of the greater reduction of carbon dioxide to carbon monoxide at such temperatures.

"The producer has water-cooled tuyeres, and the lining of that part of the producer subject to high temperature is of special brick. Back of these bricks is a water-coil cooling device, which, it is believed, will aid in preventing rapid deterioration of the lining."

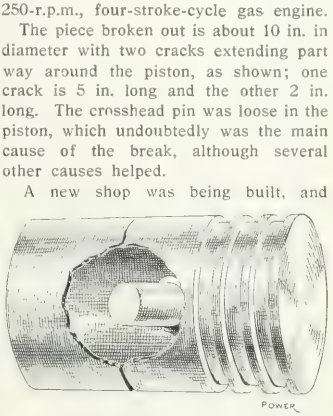
LETTER

Broken Piston

The accompanying illustration shows the location of a break in the piston of a 13x20-in. single-cylinder horizontal 250-r.p.m., four-stroke-cycle gas engine.

The piece broken out is about 10 in. in diameter with two cracks extending part way around the piston, as shown; one crack is 5 in. long and the other 2 in. long. The crosshead pin was loose in the piston, which undoubtedly was the main cause of the break, although several other causes helped.

A new shop was being built, and



Section Broken out of Piston

most of the machines were transferred to the new shop, leaving the engine running under a very light load at the time, and it began to backfire severely, which put added strain on the loose pin.

The engine had been in service 10 hours a day, for five years, and under a heavy load most of the time to within a few weeks before the accident.

M. W. Utz.

Minster, Ohio.

Clarion River (Penn.) Power Project

The Pennsylvania Water Supply Commission has announced the conditions upon which it would approve the charters of the 18 companies interested in the Clarion River power project, the general idea being that these companies will be merged into one organization later.

The companies must not build an obstruction or dam without the commission's approval; they must file a map showing the area which would be affected by the damming of the streams, and also the extent to which the reservoirs formed can be used to lessen the flood dangers in the Clarion and Allegheny Rivers. The state reserves the right to inspect the work and requires reports from two recognized engineers. The operation of reservoirs so far as floods and low water flow are concerned, are to be subject to state control.

The requirement of the United States engineers in this district as to the stored water must be lived up to, thus protecting the water supply at down-river places. The companies must also satisfy the commission within 18 months of their ability to proceed with the work.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Annual Meeting of the American Association of Refrigeration

On May 6 and 7 the American Association of Refrigeration held its annual meeting in the New Willard Hotel, Washington, D. C. Plans for the forthcoming international congress of refrigeration were passed upon and committees selected to carry on the work, new officers and committees for the association were elected and reports were made by the various standing committees.

The first session was opened at 10:30, Monday morning, with an address by President William J. Rushton, of Birmingham, Ala., and was followed by the report of the secretary, who said that during the year 54 names had been added to the 419 reported at the last meeting.

Announcement was made that E. H. Larkin, president of the Larkin & Schaefer Chemical Co., of St. Louis, and a member of the association, had offered to the David Rankin, Jr., School of Mechanical Trades sufficient money to install a refrigerating plant in the school provided it should be used in instructing its pupils in the practical operation of such machinery and in addition give a course on refrigeration. The Tait & Nordineier Engineering Co., of St. Louis, offered to make the necessary plans for the refrigerating plant without remuneration. The spirit which prompted these offers was highly commended on the suggestion of the secretary, as these actions made it possible to put in the first installation of this character under the auspices of the American Association of Refrigeration.

In addition, the secretary has, upon the request of the chairman of the board of engineers on educational work, communicated with all the schools of technology and other similar institutions in the country for the purpose of ascertaining which institutions were equipped with refrigeration machinery and also which were giving instruction on refrigeration. Many institutions expressed their willingness to extend their present courses on refrigeration and others to add this instruction. The data and replies received were referred to the board of engineers for consideration.

The most important work of the executive committee, of which Theodore O. Vilter is chairman, was the preparation of a preliminary announcement of the third international congress of refrigeration to be held during the month of September, 1913. The report outlined the objects of the congress, which in brief are to provide opportunity and means for drawing into concerted and harmonious effort of the scientific and practical men of the world engaged in developing the science and art of refrigeration, to encourage education and general progress in the refrigerating and ice industries, to determine correct basic data and standards employed in refrigeration, to stimulate investigation experiments and tests to demonstrate correct solutions of scientific technical and industrial problems, to determine the best methods of applying refrigeration to perishable foods, to encourage the expansion of trade and to study existing laws that in any way affect legitimate industrial and commercial interests employing refrigeration. This was followed by a statement on the eligibility of members, the dues and other details. The duties of the various officers and committees, rules for sessional procedure and for the handling of papers were also presented. A tentative program and a list of officers for the coming congress were offered to the association for approval.

On Tuesday the program was adopted, subject to change, and the officers suggested by the committee were elected The President of the United States agreed to act as patron and the Hon. James Wilson, Secretary of Agriculture, was made honorary president. The vice-presidents were G. H. Powell, Los Angeles, Calif.; Homer McDaniel, Cleveland, Ohio; Theodore O. Vilter, Milwaukee, Wis., and W. J. Rushton, Birmingham, Ala. J. F. Nickerson, of Chicago, was made secretary-general and James B. Forgan, of Chicago, treasurer-general.

The most extended reports of standing committees were those of J. E. Starr, chairman of the commission on testing refrigeration machinery and insulating materials, and of Peter Neff, chairman of the commission on industrial refrigeration.

The scope of the work of the commission headed by Mr. Starr has so far included methods of testing the capacity of refrigerating machinery; first, by brine circulation, where the total work of the machine is used for cooling brine, and also by testing the weight of the working fluid condensed and evaporated in machines using a liquefiable gas. The methods under consideration are weighing liquids in alternative receivers and also measuring in alternating calibrated receivers from gage-glass readings.

The commission is collecting data on the average relation of the actual amount of fluid handled by various types of compressors to the nominal displacement figured from the dimensions and speed of the compressor in order to establish as far as possible an approximate standard volumetric efficiency, and therefore an estimate of capacity.

Efficiency tests, showing the relation of power used per unit of refrigeration accomplished, is another subject on which the commission is working and it is also looking into the strength of materials and methods of construction, standardization of fittings, surfaces, etc.

It has taken up the various methods of testing insulation heretofore followed by different investigators and concludes that the most practical data desired are:

1. Transmission of air from one side of the insulation to air on the other, both in fan-induced moderate circulation.

2. Transmission from air on one side to air on the other side, both in natural circulation.

3. Transmission from warm air on one side to a cold liquid on the other, the liquid practically quiescent except for circulation set up by convection in the liquid.

4. Transmission from warm air on one side to a cold liquid on the other at various rates of speed of liquid against the surface.

5. Transmission from air through insulation to the cold liquid in pipes at various rates of speed of the liquid.

At a later date, the commission hopes to report its recommendations on the following points: number of square feet of insulation to be considered as standard for tests, location and number of thermometers per square foot, distance of thermometer bulbs from the surface of the insulation, methods of measurement of the amount of heat conditions as to moisture, and arrangement of test apparatus that may be deemed standard.

It has been greatly hampered by the great difference in various tabulations given by different authorities as to the properties of working fluids used in refrigerating processes. It has endeavored to secure the best and supposedly most correct tabulations, but on submitting them to physicists in this country it met with a still wider difference of opinion from these reviewers. For instance, in

the case of carbon dioxide the difference in calculation in some cases runs as high as 20 or 30 per cent. Even the standard unit, the latent heat of fusion of ice, varies from 142 to 144 B.t.u., or about 1.4 per cent. The association was asked for instructions as to what standards should be used in carrying on the work and will probably be informed by the commission on standards in due course.

The duties of the commission on industrial refrigeration, headed by Mr. Neff, are to answer inquiries as to the uses of refrigeration, to collect information on the subjects called for and make suitable response either in the form of a letter or a bulletin, giving the inquiry and the reply. A sample bulletin was presented at the convention in which the information solicited was answered very fully and in convenient form.

A resolution of regret was read over the death of J. deLoverdo, secretary-general of the International Association of Refrigeration, and a request from the French association for a contribution for Tellier was granted. In France, Mr. Tellier is styled the father of refrigeration, but the American association was not willing to concede this as a number of men antedated him in this country.

On Tuesday the various delegates convened at the Bureau of Standards and listened first to an interesting address by Dr. Stratton on the work of the bureau. The address was followed by a long discussion on ways and means of securing an appropriation from Congress which would enable the Bureau of Standards to carry on the work so badly needed of standardizing refrigerating data.

A. M. Howser, of the Crane Co., then read a very interesting paper on the standardization of flanges for ammonia refrigerating equipment which, due to its length, will be presented in a separate article. A committee was appointed to consider Mr. Howser's plea for standardization.

The election of the association officers closed the business of the meeting. The results were as follows: President, W. J. Rushton, Birmingham; vice-presidents, E. O. McCormick, San Francisco; Thomas Shipley, York; Jacob Rupert, Jr., New York; Homer McDaniel, Cleveland; W. McCochran, Indianapolis; George L. Flanders, Albany; R. H. Tait, St. Louis; secretary, J. F. Nickerson, Chicago, and treasurer, John S. Field, Chicago. Chairmen of the various committees and commissions were also elected.

Luncheon was served at the bureau and afterward the delegates were split up into several parties and conducted through the various buildings of the institution. The present work carried on by the bureau was inspected with a great deal of interest. Its variety and character were surprising and some intimation was obtained of what might be done with a larger appropriation.

The Value of Expert Advice

By T. H. Reardon

In nearly every business proposition today it is of the utmost importance before any disbursement of cash occurs that the party contemplating a business venture, be it steam, electrical, hydraulic, artificial refrigeration or any one of a hundred different things in the technical line, should have the advice of a man thoroughly competent to advise and who is at the same time independent and impartial. A failure to have proper regard for such fundamental principles, has caused many a man to part with his hoard, or at least a good portion of it, in accepting the gold brick that the wily salesman has to offer.

The manufacture of artificial ice with cold storage as an important adjunct in a certain New England city forms the groundwork of the following narrative: The board of trade in any city has got to be recognized as the exponent of all that pertains to a business venture. This is the popular verdict at least, and while success is highly lauded, the failures that abound in the schemes fostered by boards of trade are usually given a very quiet interment with none other than the immediate relatives in attendance.

Artificial ice making is, under certain conditions, a paying proposition and the investment of money in such an enterprise is in no way to be discouraged, but it does make a vast amount of difference where the plant is located.

The board of trade in a certain city decided that it should have a new enterprise, and as an artificial-ice plant seemed to be the only thing that would lower the temperature of the enthusiasm that prevailed, bids were solicited, offers were considered and a $30,000 ice plant of the absorption type was soon under headway. The building was rushed to completion and soon triple-refined ice was offered the fastidious public at the same price as the common article that nature furnished by the square mile in northern latitudes.

The ice was free from bacteria and air bubbles, and was highly transparent, and the argument that it was slow-melting and therefore economical appealed to the good housewife.

In a short time the slow-melting properties of the ice, instead of giving impetus to its sale, had the opposite effect. Culinary incumbents understood in a sort of practical way that the ice was not borrowing heat units from the surroundings and the cooler temperature failed to touch the low mark. The natural ice again had ascendancy on account of its readiness to liquefy without any special instruction to do so.

The plant continued to make ice for about a year under conditions that gave the largest possible output for the amount of capital invested, but it was not on a paying basis. Then artificial-ice making was cut out and cold storage was maintained for three or four years, likewise on a nonpaying basis. The plant was finally shut down so far as refrigeration was concerned and the sale of its equipment was closed out to a shrewd dealer in second-hand machinery and old junk. He had a smile of satisfaction on his face as he informed the writer that he had recovered about a thousand dollars' worth of ammonia that was overlooked by the selling party and himself at the time that the deal was consummated. The stock of calcium chloride has not been heard from, but in all probability there was enough of it to yield considerable revenue.

Good, sound technical advice at both the commencement and the finish would have paid for itself and left something for the owners, but in this case, as in many others, the leading business man or the prominent townsman felt the sufficiency of his own knowledge to such an extent that he really did not need to load himself down with any data that an engineer could furnish.

Standardization of Flanges for Ammonia Refrigeration Equipment*

By A. M. Howser†

The manufacturers and users of valves and fittings for ammonia refrigerating plants have for some time realized the necessity for a universal standard for flanges. Existing conditions in this work have conclusively demonstrated the necessity for such a standard, and the experience of manufacturers and consumers of steam goods in the standardization of flanges has brought this matter out more forcibly. A short summary of the history of the standardization of flanges and flanged fittings for steam and water is in order at this time.

As far back as August, 1894, the Master Steam and Hot Water Fitters' Association and the American Society of Mechanical Engineers, together with the manufacturers of valves, fittings and pipe, at a conference of committees, adopted a standard of dimensions for pipe flanges, in sizes 2 to 48 in. inclusive, for standard working pressures. While this standard was originally designed for 200 lb. working water pressure, it is generally accepted by the engineers and manufacturers throughout the United States for steam working pressures up to 125 lb. This standard is printed in "Kent's Handbook," pages 197-198, 1910 edition.

Previous to the year 1901, the manu-

*Paper read before the American Association of Refrigeration, Washington, May 7.

†Mechanical expert, Crane Co.

facturers of extra-heavy flanged fittings for steam did not have the same standard. This was a source of inconvenience to consumers and manufacturers alike. Realizing the necessity for a standard, a conference was held on June 28, 1901, at which were present representatives of the various manufacturers. At this conference an extra-heavy standard of sizes 2 to 24 in., inclusive, was adopted and all manufacturers and the majority of steam users are using it at the present time.

A committee of the various manufacturers of steam and water goods are now conferring with the Master Steam and Hot Water Fitters' Association and the American Society of Mechanical Engineers regarding a few proposed changes and additions to the generally accepted standard for flanged fittings, and it is expected that an agreement will be reached in the near future.

The history and development of the standard for steam and water goods is an excellent guide to the manufacturers and users of valves and fittings for ammonia-refrigeration plants, as the same problems present themselves at this time in the standardization of flanges for ammonia goods as have been met with and solved in the standardization of steam flanges. The disadvantages resulting from the existence of numerous ammonia standards now in use are no doubt apparent to both the manufacturers and the consumers. The consumer is put to constant annoyance and inconvenience, because in replacing valves or fittings in his plant he must buy goods from the original manufacturer, or else have them made special with the proper flanges. This naturally causes delay in making repairs and frequently entails considerable additional expense, because of special goods which must be made up to fit the existing standard. And the inconvenience to the consumer is not confined entirely to obtaining repairs for his plant. When several different standards for flanges exist, a consumer who contemplates building a new plant must necessarily exercise extreme care in selecting goods which will be of undoubted quality. As some standards may be lighter or heavier than others, it is naturally a doubtful question as to which standard is right, and the consumer frequently runs the chance of obtaining goods of inferior quality as regards strength of flanges and bolting.

Where a universal standard is adopted by the manufacturers, it being the result of the combined experience of manufacturers, consumers and engineers, the inconvenience to the consumer in making repairs and additions to his plant is reduced to a minimum, as the goods of all manufacturers will then be interchangeable. Furthermore, there will be no doubt in the mind of the consumer regarding the strength of flanges and bolting.

The existence of several standards is annoying and inconvenient to the manufacturer as well as to the consumer. It frequently prevents the former from obtaining business in a particular plant, because his standard for flanges will not interchange with the standard in use in that plant. Furthermore, it necessitates the manufacture of a greater amount of special goods with flanges made to interchange with some other manufacturer's goods.

In adopting a new standard several very important points must be given careful consideration.

1. It must be based upon the experience not only of the consumer but also of the manufacturer. A purely theoretical standard which does not take into consideration all the conditions met with in the manufacture and use of the goods would obviously be of little value.

2. It should provide the consumer with goods of ample strength and quality for all working conditions, and be of a design which will be thoroughly practical from a manufacturing standpoint and economical in cost of manufacture. The change in standards should entail as little expense to the manufacturer in changing his pattern equipment as possible, but, of course, it is realized that where so many standards exist, it is necessarily a difficult matter to adopt a new standard which will not require a radical change on the part of a majority of manufacturers.

The difference in the standards for flanges of the various manufacturers are very wide. The number and size of bolts and the strength of bolting are very different; the bolt circles do not agree, nor does the shape of flanges for a given size. Some manufacturers use a square flange, others a scallop or a round flange, and still others an oval flange. The dimensions of the tongues and grooves are also widely different.

In general, in adopting a new standard the experience of the trade in reference to the strength of bolting, the shape of flanges, etc., should be taken as a guide; but it will be a difficult matter to effect a compromise between the various manufacturers in the matter of detailed dimensions. In other words, it appears as if the problem resolves itself into adopting a standard which experience has proved satisfactory and considering the matter of expense in changing patterns as a secondary consideration.

The Crane Co. started to manufacture valves and fittings for refrigeration plants over eight years ago. At that time the same position was confronted that this body now realizes; as the company was fully aware of the confusion existing among the various manufacturers. At the time the necessity for a universal standard was realized and after careful investigation a standard was adopted, the quality of which was considered fully commensurate with the severe service to which these goods are subjected. Briefly stated, the standard for extra-heavy end flange bolting, which had been agreed upon by the manufacturers of steam goods on June 28, 1901, was adopted; this applied on sizes 1 in. and up. As the manufacturers had adopted no standard for a smaller size, two-bolt flanges on sizes ¾ in. and down were adopted. The shape of the flange was made oval where two bolts are used, square for four bolts and round for eight bolts. The flanges were chamfered on the face, which was in accordance with the generally accepted practice for ammonia goods.

In view of the fact that various styles of joints were being used throughout the trade, it was decided to furnish goods made up with four different styles of joints, as follows: Tongue-and-groove, Boyle, screwed end and screwed end with gland.

In adopting the dimensions for the diameter of the tongue-and-groove and the Boyle joint, the diameter of the tongue was made the same for either the Boyle or the tongue-and-groove joint. The inside diameter of the tongue, therefore, was made slightly larger than the outside of the pipe, and the outside diameter of the tongue was made large enough to provide liberal gasket area.

In deciding these joints the practice of all the leading manufacturers as well as the engineering profession was considered. Furthermore, a standard location for the tongues and grooves was adopted as follows: Globe, angle and cross valves were made groved on the inlets and tongued on the outlets. Elbows were made tongue-and-groove. Tees were made tongue-and-groove on the run and tongue on the branch. Return bends were made tongue-and-groove.

A standard center to face and face to face for both valves and fittings was adopted, thus making it possible to put a valve in place of a fitting, or *vice versa,* without changing the piping or flanges.

While the demand is limited on sizes 7 to 12 in. for ammonia, there are calls for these goods, and as the standard used for extra-heavy steam is practically the same in Germany, England and the United States, as well as the United States Navy, it would therefore seem reasonable to use and adopt the extra-heavy steam dimensions on all sizes for ammonia work.

Specialization and scientific management, says London *Engineering,* have come about by a process of natural development, and have not been imposed upon society as a cut-and-dried system or a worked-out thesis. It is simply a case of picking out the good things as they come.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Co-operation in Power Plant Testing

In most power plants some form of record is usually kept that will show the performance of the plant as a whole from day to day. These records are of value for checking costs from month to month and also for comparison with the results obtained in other plants of similar size. If suitable recording apparatus has been installed, the performance of various groups of machines can be studied as well as that of the whole plant.

The only criticism that might be made here of such a system is that these records are not always available for publicity in the technical press, where they would create competition among engineers by showing what other fellow-engineers have done and would thus act as a stimulus to economy.

While such records show the performance of the plant as a whole, or of only certain portions, from day to day, they are not always suitable for the study of the performance of individual machines, of their alterations or of different methods of handling them. For instance, supposing it is desired to study the effect of changing the baffling of flue gases in a boiler, the method of firing, smoke consumers, or the effect of a change in the vacuum on steam engines or turbines, such studies can best be made by special tests. Most plants are not provided with the necessary apparatus or extra help for making extensive tests, and, besides, such tests are often expensive to carry out; therefore, in many cases a force of sufficiently skilled observers would not be available in a single plant. It is evident, then, that there are many obstructions and difficulties in the way of the isolated-plant engineer who desires to make tests in his own plant.

This problem has come up in other countries and has been solved in a very simple manner in Germany, where the engineers have formed societies at local points to coöperate with one another in power-plant testing and to jointly own all the necessary test apparatus for making complete tests on engines, boilers and auxiliaries. They have had the moral and, to a certain extent, the financial support of the plant owners in this work. All their tests are made with the greatest care and the results are accepted as accurate by the engineering world. Studies are made of the various forms of stokers, furnaces and smoke-consuming devices, of the methods of burning certain grades of coal, of different types of boilers, engines, turbines, etc., and of other power-plant apparatus. This work all leads to closer study of power-plant problems and to keener friendly rivalry between the engineers of isolated power plants.

Similar steps have been begun, on a smaller scale, by a number of the operating engineers' societies in this country, but in most cases the available testing apparatus is limited. What is needed is more active coöperation and a large scope of the activities in this line.

Fire Drills in Power Plants

The desirability of fire drills in power plants employing enough men to require organized work in case of an incipient blaze needs little argument. Where such drills have been tried and maintained through long periods without interruption, many lessons have been taught to the alert engineer.

Some of the causes of poor protective service are indicated in the following difficulties with which the staff had to deal in the case of a company which has for nearly a decade been keenly interested in improving the protection of its physical property. In one test, the hose burst almost as soon as it was subjected to water pressure. In another, the fire-alarm gong rang so feebly that it could not be heard more than a few feet away from the wall where it was located. Failure to get water, neglecting the valves or opening them only part way were also noted by the inspecting engineer as ob-

stacles to efficient fire fighting. Again, bad couplings were made in the hurry of the test, the hose also being laid with kinks and sharp bends which prevented the prompt delivery of water. In another instance, the fire-doors stuck and the shift on duty displayed poor team work, as there was no leader in attacking the imagined blaze; ignorance of the location of extinguishers and of the auxiliary city alarm also existed.

These points are most important in the first few minutes of a fire, and every operating engineer who is alive to his responsibilities and prepared to handle such emergencies will see to it that his force, through conscientious drilling, does not commit such hasty and ill-considered acts as were found in the single instance above outlined.

Western Big Things

The grand scale on which everything is done in the West is always a marvel to the uninitiated. It is a characteristic of the Westerner to be bolder in his undertakings than his cousin of the East. He is accustomed to think in larger figures than the conservative Easterner whether it is in acreage of farm or orchard, if he is an agriculturist, or size of power development, or length of transmission line, if he is an engineer.

It is particularly in the utilization of the wealth of available water powers that notable strides are being made on the distant side of the Rocky Mountains. With the increasing cost of coal confronting us, not only by the gradual depletion of the sources of supply, but the shortages that may come temporarily at any time from labor difficulties, to say nothing of the monopolistic control of the production and distribution, it behooves all sections of the country, and of the world for that matter, to acquaint themselves with progress in the hydraulic generation of power.

The importance of this subject has made it seem justifiable to devote considerable space in this issue to an account of one of the most notable power-generating systems in the world, that of the Pacific Gas & Electric Co. (page 720). While this company's plants are not all hydro-electric, twelve out of its total fifteen are, and the territory it serves covers nearly 38,000 square miles and includes 204 cities, towns and villages. The article is one we can commend to the attention of all engineers interested in that vital problem of more and cheaper power.

Obeying Orders

The enforcement of orders is one of the difficulties chief engineers encounter. Even though every other man on the force follows instructions and one does not, the chief never knows that the conditions about the plant are as they should be.

Not infrequently disobedience of orders results fatally and more often in serious injury to fellow workmen. It is bad enough that carelessness is sometimes responsible for these conditions, but more often orders are wilfully ignored so that the individual may escape a slight inconvenience.

At the Redondo power plant, on the Pacific coast, an installation that probably earned a larger bonus for its builders than any other in the world, the use of oil-burning lanterns about the premises is absolutely prohibited because of the danger from fire due to gases arising from the fuel oil used in the boiler furnaces.

Oil for immediate use is stored in auxiliary concrete reservoirs placed outside of the building. To facilitate its separation from the oil, the water is heated to a temperature of 80 deg. before being pumped to the oil heaters where the temperature is raised to 130 deg. F.

Electric lights are so arranged that they illuminate the thermometer placed in each tank, thereby removing any excuse for taking a lighted lantern on the platform covering the tank. This rule was disregarded, and as a consequence, five men were severely burned.

Briefly, the cause of the accident was a broken incandescent lamp which illuminated one of the tank thermometers, and rather than replace it with a new one the tankman hunted up an oil lantern, and went on the tank platform, when the gas arising from the oil ignited.

A fireman who knew that the tankman was in the tank attempted a rescue and was caught in a second explosion. Then three others, one of whom was the chief engineer, in rescuing the first two men were also caught in the burning oil. With one exception, these men were dangerously burned.

This accident was the result of one man's carelessness and disobedience of orders.

Concerning Our Study Questions

Our study questions, first printed as an experiment, have been so well received that, in response to expressions of appreciation and requests for more, we have decided to give five every week instead of every other week. The answers will appear one week later as before, so that each week we will have the answers for the previous week's questions and five new ones. We have also given the questions a more conspicuous head like our various departments and they will hereafter appear in the same part of the paper so that they can be quickly found by those interested.

These questions are not to be confused with the "Inquiries of General Interest," for they will generally be of a different nature and a different motive exists for printing them. With the inquiries the answers are given at once so that there is not the same incentive to work out one's own solution. The study questions are not intended primarily as direct helps in working out your special problems for you have the "Inquiries" department for that, but rather as exercises for one's thinking powers, to cultivate alertness, observation and common-sense reasoning —in short, brain developers. On this account they will not be confined to any one class, but the object will be to give an assortment that will contain something of interest to all, mathematical, geometrical, general. Many may be somewhat in the nature of puzzles, but it will not be the purpose to confuse or make them in any sense tricky, as by plays on words, nor will any incomplete problems nor ones impossible of solution be given.

If you like this department we will be glad to have you write us, and any suggestions as to kinds of questions you would like to see or specific ones you would like to submit will be welcome.

A Baltimore inventor has discovered the hollow bridge-wall. His advertisements announce that "it will burn 30 per cent. air instead of coal." Better be getting in your winter supply of air.

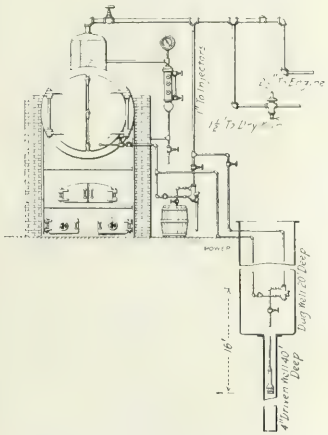
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Improving a Neglected Plant

In a Western plant I found the equipment in bad condition. The engine was pounding and gave forth a peculiar rattle which the engineer said he could not eliminate.

With the fireman as helper, I equalized the clearance, which was nearly all on one end. On removing the steam-chest cover I found the springs that held the pressure plate on the valve to be considerably worn at the ends. The engine was next put on both centers and the valve given the required lead by adjusting the eccentric which had slipped about ¾ in. from its correct position. The application of a straight plate showed the springs to be so worn that the edge was allowed to slam and cause the annoying rattle. By putting pieces of ½-in. round iron into the four holes in the plate in which the springs were placed the proper tension was obtained. The steam-chest cover was then replaced, and the crank and main bearings adjusted as the lost motion was causing much of the pound.



ARRANGEMENT OF BOILER ROOM PIPING

The boiler room was laid out as shown in the accompanying illustration. The steam opening in the boiler dome was 4½ in., which had been reduced to 2½ in. A number of branches were taken off this line which then continued on to the engine, which required a 2¼-in. steam pipe. The feed pipe had been reduced from 1¼ in. to 1 in. and entered through the front head, discharging immediately over the fire. One of the injectors worked well, but the other did very little work. Examination of the suction pipe which took water from the barrel, showed that it had been reduced from 1 in., the correct size, to ½ in. This pipe was changed to 1 in. for its entire length, and a 4½-in. header put in at the boilers; a reducing valve was also put on the line to the dry kiln, thus eliminating the practice of regulating the pressure by hand.

The changes made resulted in quiet running equipment and the economy obtained amply paid for the expense of the alterations.

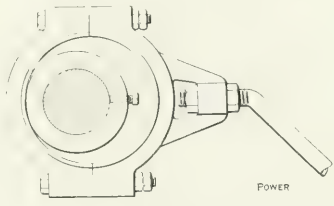
C. F. KING.

Portland, Ore.

Accident Bends Eccentric Rod

Not being satisfied with the operation of one of his engines, a certain engineer borrowed an indicator and, assisted by another engineer, proceeded to attach the instrument and take diagrams. As the machinery in the shop was operated every working day, he had to do this work on Sunday. After taking a pair of diagrams he decided to improve matters by moving the eccentric forward on the crankshaft. It was necessary to loosen the setscrew in the governor pulley and move it toward the flywheel before the eccentric could be loosened.

Having adjusted the eccentric, he quickly moved the pulley back as far as it would go, tightened the setscrew, and started the engine. An unusual noise called his attention to the eccentric, and he closed the throttle valve. As the crank stopped, a large piece of cast iron, broken out of the rim of the pulley, fell to the floor. It did not run perfectly true, and being closer to the eccentric than usual, it had caught the shank and bent the rod as shown in the illustration.



BENT ECCENTRIC ROD

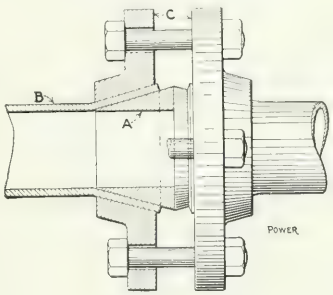
An attempt to heat the bend with a gasoline torch was not successful. The inner nut was then removed, the rod taken out, the second nut unscrewed and the rod was then heated in an old hand forge. In order to prevent bruising the threads, one of the cool nuts was screwed on, after which the hot rod was straightened with a hammer. It was then replaced, the nuts adjusted and more diagrams taken, which showed that the valves opened at the proper time to give good results. The rod showed no ill effects of its heating in the forge.

W. H. WAKEMAN.

New Haven, Conn.

Serviceable Pipe Joint

In a large hotel the entire hot-water system was installed with galvanized-iron pipe which, after considerable service, was the source of much trouble. The lines leaked at the joints and through holes in the pipes and did much damage to the hotel furnishings.



FERRULE PIPE JOINT

The old pipe was removed and extra-heavy solid-drawn copper pipe put in. The system was of the return-flow type and, as the boiler was fired very irregularly, the expansion and contraction were extreme. Despite such unfavorable conditions, the new piping and joints have thus far exhibited no signs of leaking. This satisfying result is due mostly to the type of joints used, which, while rigid, are flexible enough to allow for the expansion and contraction.

In the illustration, *A* is a brass ferrule, the face of which has the same diameter as the pipe. The sides are tapered to about 15 deg. and fit inside the pipe as shown at *B*; the flanges are shown at *C*. To make the joints the flanges are slipped over the pipe and the latter hammered to form the bell-mouth ends. The ferrule is then given a coat of red

lead and entered into the ends of the pipe, and the flange is then drawn tight to complete the joints. This installation was expensive, but the management feels that the results justify the investment.

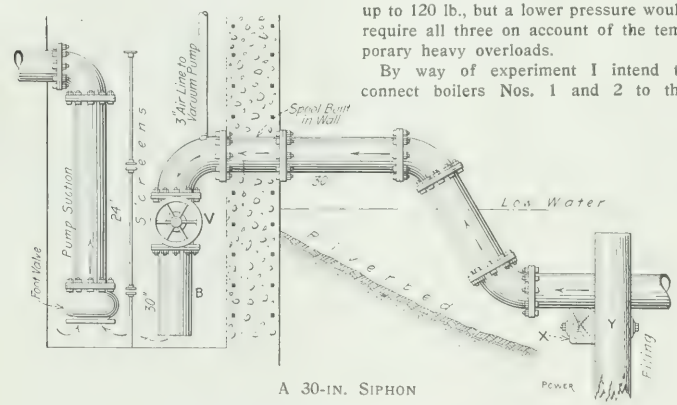
O. G. A. PETTERSSON.

Manitoba, Can.

30-in. Siphon

The accompanying illustration shows one of four very interesting siphons used in connection with the condenser equipment of a Western power house. The siphon is built of 30-in. cast-iron pipe, and the section shown under water is 24 ft. long. It was built before being lowered into the water, after which the cross-pieces *X* were fastened to the pilings *Y* by a driver. The leg *B* is about 12 ft. long.

To start the siphon at low water it is only necessary to draw the air out by means of the 3-in. pipe shown attached to an air pump. With the water in the well about 2 ft. lower than the river, one of these siphons will pass about 24,000,000 gal. every 24 hours. They will run from three to five months without "breaking"; that is, losing the water—unless the quantity pumped from the well is reduced to about 5000 gal. per minute, when one out of the 4 will stop flowing. This is perhaps due to the fact that the velocity of the water is so reduced that it will not carry the air down with it in the leg *B*.



A 30-IN. SIPHON

On the other hand, if the water is drawn out of the well so rapidly that the level is within a foot of the end of the leg *B*, it will break again, owing to the violent agitation of the water at that point, thus allowing air to back up the drop leg, in which case it is necessary to use the air pump every six or eight hours.

The valve *V* is used only during high water or in case it is desired to clean the well. During low water it is only necessary to admit air to the siphon through the 3-in. pipe to stop the siphon. The valve *V* has its valve stem extended to the floor above high-water mark.

The method of screening the water is by means of bar screens of 1-in. mesh. There are four of these siphons in the pumping station, which has a daily capacity of 60,000,000 gal. against a 32-ft. head.

EDWARD H. LANE.

Kansas City, Mo.

Plant Economy

I have three 125-kw. dynamos direct-connected to high-speed engines, a steam-driven duplex air compressor rated at 200 hp., four 250-hp. water-tube boilers, each connected to a 14-in. steam header and also to a smaller auxiliary header which supplies steam through a reducing valve at 75 lb. to the pumps and to all live-steam lines.

The engines are designed to operate at a pressure of about 100 lb., but will run well and carry 50 per cent. overload at 160 lb.; they will also carry their rated load with a pressure as low as 75 lb. The load is such that I can carry it on two units by keeping the pressure up to 120 lb., but a lower pressure would require all three on account of the temporary heavy overloads.

By way of experiment I intend to connect boilers Nos. 1 and 2 to the main header and disconnect them from the auxiliary header by closing the valve; connect boiler No. 3 to the auxiliary header and disconnect it from the main header by closing the valve. Boiler No. 4 is out of service but it can be connected to either header if I simply manipulate the two valves; disconnect the air compressor from the main header and connect it to the auxiliary header. All the units now exhaust into one main header. I will rearrange this piping so that the engines will exhaust into No. 3 boiler; the compressor and pumps will exhaust as at present into the vacuum-heating system and open feed-water heater.

My plan is to run Nos. 1 and 2 boilers, supplying steam to the high-speed engines, at 150 lb. and have them work against a back pressure of 75 lb., leaving an available working pressure of 75 lb., which will necessitate running the three generating units. The air compressor, pumps and live-steam lines will take steam from the auxiliary header at 75 lb.

The auxiliary header will be equipped with a back-pressure valve specially designed for 75 lb., providing the 4-in. pop valve already on should prove too small to relieve it at times of overload.

I expect that by using the high-speed engines as reducing valves, a saving of 25 per cent. will be realized. I am anxious to learn how many of the interested readers will agree with me.

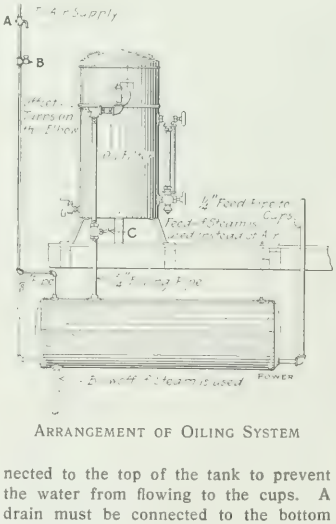
W. J. BAILEY.

Bedford, Ind.

Simple Oiling System

To save time and trouble in filling oil cups on high-speed or large engines the oiling arrangement shown in the illustration may be installed. By its use all the oil cups can be filled in less time than it formerly took to fill the oil can.

This outfit is operated by compressed air, but steam may be used if air is not available by connecting it as shown in the dotted lines. Provision must then be made for drawing off the water of condensation from the bottom of the tank, and the oil outlet should be connected to the top of the tank to prevent the water from flowing to the cups. A drain must be connected to the bottom of the tank to draw off the water.



ARRANGEMENT OF OILING SYSTEM

To operate with compressed air, close the air cock *A* and open the vent *B;* then open the filling cock and swing the offset under the faucet on the filter. After filling the tank, close *C* and *B* and open *A*. The offset may now be turned away from the faucet so that other receptacles may be filled from the filter.

J. A. LANE.

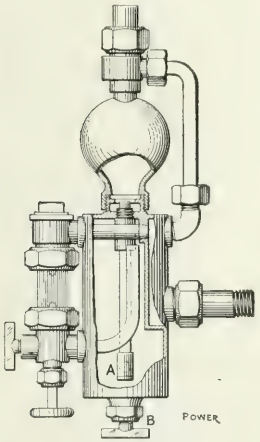
Meriden, Conn.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Oil Pump and Lubricator Filler

In the Apr. 9 issue, W. E. Stickney comments on my letter under the above title in the Jan. 23 issue. I agree with him in most of his statements, but he seems to forget that lubricators differ in their construction and operation.



CONSTRUCTION OF LUBRICATOR

Mr. Stickney states that it is not necessary to drain the body of the lubricator through the drain-cock when filling it with oil. That may be true of his lubricator, but not of mine; it is impossible, as shown by the accompanying illustration, as water could not be forced beyond the check valve *A*. With a lubricator of this construction it is necessary to drain it by opening the drain-cock *B*.

MARTIN MCGERRY.

Holley, N. Y.

Boilers Transfer Water

W. E. Warner's boiler puzzle in the Apr. 9 issue may be rather hard to answer if one is not acquainted with the plant in question.

It is obvious that if No. 1 was the best steamer, it surely would not get the water from No. 2, as No. 1 would evaporate more water and the water level would be more quickly lowered. My experience is that the boiler which is doing the least gives the least resistance to the water coming into it. In a battery of three boilers I found that the one next the stack evaporated water much faster than either the second or third boiler, and that in order to keep the fire equal it would have been necessary to regulate the draft so as to give the one next the stack no more draft than the other two.

In this case, if No. 1 boiler is next the stack and a long-bend steam pipe is used, I fail to see how it can pull water from No. 2.

JOHN LEONARD.

Columbus, Ohio.

Moyer's "Power Plant Testing" Defended

In a recent number of POWER there appeared a rather severe review of J. A. Moyer's "Power Plant Testing."

To a broadminded reader it is evident that this book was written with the object of conveying to the student first entering a mechanical course, the underlying principles concerning the testing of various machines and engineering materials. To explain the why and wherefore of engineering things is not easy, and must of necessity be approached through laborious and winding channels, which to the experienced theorist seem to be unnecessary, since he is familiar with the cuts, and, therefore, loses sight of the fact that the beginner must be led slowly and painstakingly.

Another group this book is intended for is the operating engineers. We all know that an operating engineer, like myself, is well acquainted with the operation of the various machines under his supervision, which familiarity was obtained only through years of intimate contact with them, and the operation has become more a matter of habit rather than an analytical process of thinking of what he is doing. As for the testing of these machines, the average operator is blissfully ignorant, as is attested by the many rudimentary articles on testing various machines appearing in POWER from time to time.

That a "long felt want" has been filled by the book in question is confirmed by the fact that technical schools all over the country, with prejudiced exceptions, have adopted it both as a textbook and laboratory guide, and very many operating engineers like myself have learned to appreciate it most highly.

In justice to the author and to many other practical engineers, including the writer, I sincerely trust that you will find space in your columns for this letter.

A. LINKER.

Brooklyn, N. Y.

Advertisers, Catalogs and Follow-up Methods

The contributions of Messrs. Bailey and Dickson on the above subject in the issue of Feb. 27 are true to reality. Some firms do object to their engineers receiving catalogs, etc., at the plant, but most concerns are glad to use the knowledge the engineer gained by their use.

I always have such correspondence sent to my home address, and discourage the sending of follow-up letters. I cannot understand why some manufacturers are reluctant to forward catalogs of their product when they are requested by interested engineers. The request is an indication of progressiveness and frequently means an eventual sale. When a request is flatly ignored it antagonizes what otherwise might have been a good customer.

Recently I employed a man to care for our belting. He was one of a large number of applicants and was put on because he said he was thoroughly familiar with a well known belt dressing and with belt-lacing machines; he was.

The mistake made by many advertisers lies in sending follow-up letters before there is really anything tangible to follow.

J. PARNELL.

Belfast, Ire.

Cost of Power in New England Mills

Mr. Brinckerhoff's article on the cost of power in New England mills, in the Apr. 9 issue, is interesting but somewhat misleading. He makes the statement that under motor drives the shaft friction would be 15 per cent. This is evidently an error.

If it is assumed that the friction loss in each line shaft is 15 per cent. in any mill, it will mean that for the total mill the loss will be far greater than 24 per cent. as found in the Fitchburg Yarn Co. The reason for this is that the friction losses in a belted plant are cumulative—that is to say, the engine not only has to supply the power to each line shaft, but it also has to supply the power which may be used up in friction from

one shaft to another. Taking the shaft farthest from the engine, it may require 20 hp. to run the machinery at this shaft, and if the friction loss is 15 per cent., the total power required to supply power to it would be 20, plus 15 per cent. of 20, or 23 hp. The next shaft also supplies power to machines of 20 hp., and it must therefore transmit 43 hp. The total power required to drive this shaft would be 15 per cent. more, or 49 hp., and so it would go from shaft to shaft. With electric drive, this condition of affairs does not exist.

If Mr. Brinckerhoff will carry this process through the large number of shafts in a yarn mill, and allow 15 per cent. loss, he will find that the total losses under these conditions would be nearer 50 per cent. than 24.

There is no reason why, with properly laid out shafting and belting with group drives, the loss should exceed 5 per cent. The loss from the motor to the line shaft can be made very small by properly adapting the drive, using either chain, rope or belt, and the loss from the shaft to the machines can be made equally small if the conditions are rightly assumed and properly laid out. The motor efficiency will depend largely on the speed and frequency, but in motors of the size selected it should not be under 90 per cent. The loss in the line if the wiring is laid out as it should be will not exceed 1 per cent., making the total loss but 16 per cent.

Mr. Brinckerhoff also states that the friction loss in the Fitchburg Yarn Co. was 418 hp., or 24 per cent., showing an excellent condition of drive and one which would be very hard to beat under conditions of belt drive. The figures, however, are misleading, inasmuch as they were obtained without any load upon the shafting; friction will increase materially with the load, so that at least 20 per cent. should be added to this friction loss to cover loading the shafting. This would make the total power loss 502, or 28.8 per cent. and leave 1242 hp. to operate the machinery. This 1242 is the indicated horsepower required to drive the machinery. The actual mechanical horsepower would be 93 per cent. of this if the mechanical efficiency of the engine is 93 per cent.; this would leave 1155 hp. required at the machinery, or 1375 electrical horsepower at the switchboard, or, at $22.50 per horsepower, a total cost of $30,937.50.

The present cost of power is $29,090, showing a saving of $1847.50 for the present method of drive. This is quite different to the figures given by Mr. Brinckerhoff, and proves that conservative figures would not show such a decided saving for the present method of operation. In addition to this, as he states, there should be added the interest on the cost of the equipment, and the coal required for heating and other purposes, in order to make the comparison a fair one; but at the prices submitted, the electric drive cost of power is nearer the belted drive than in the figure submitted by him. With the belted drive it is very uneconomical to operate the plant in small sections, as the friction loss is excessive; whereas, by the electric drive, small sections can be operated as economically as the large ones, provided the cost of power is on a flat-rate basis.

It would be interesting to make a careful examination of the conditions that exist in the Fitchburg Yarn Co., to see what could be done by operating this plant electrically, power being supplied from its own plant. It is evident from the figures given that it would not be economical for the company to purchase power at the quoted price, but these figures do not show that it would not be economical for it to operate its own plant electrically.

Mr. Brinckerhoff states that it will take 1 i.hp. to drive 4.5 looms, while for the electric drive the same power was consumed to drive 3.4 looms. Does this mean that it took 1 i.hp. to drive 3.4 looms under conditions of electrification? If it does, it is evident that the plant was not properly laid out.

In many plants the electric installation has been too elaborate, individual motors being used in some instances where they are entirely unwarranted, or motors direct-connected to a line shaft operating at such a slow speed that the motor efficiency was necessarily bad. Under conditions like this, poor economy is inevitable.

HENRY D. JACKSON.

Boston, Mass.

Why Lubricator Will Not Work

Referring to Mr. Hull's illustration in his letter in the Apr. 2 issue, valve *C* has nothing to do with the working of the lubricator. Its proper place is next to the main steam line; here it may be shut off if work is to be done on the pump or line. Valves *D* and *B* should be located within 24 in. of the pump; valve *B* ought to be placed where it formerly was, and valve *D* left undisturbed. If there is a valve on the pump steam line, valve *C* may be discarded.

The lubricator should be left where it is and the U-bend removed and a small pipe used to connect the condenser and the steam line. This pipe should have a vertical length of about 24 in. and be provided with a valve. Plug the lower steam connection left open by the removal of the U-bend by using a blind gasket. The lubricator will then give good service.

M. C. REYNOLDS.

Carey, Ohio.

If Mr. Hull will note the way he has his lubricator connected up, he will find that he ought to connect the condensing line from the lubricator above the throttle valve; then it will work satisfactorily and feed both pumps without further trouble. As at present connected the lubricator does not get enough boiler pressure steam for condensation to fill it up as the oil goes out.

My experience is that there may be too little or too much condensation in lubricator practice. It depends on the location; if it is in a warm place it takes more condensation pipe than in a cold place.

JOHN K. VOGLER.

Ellwood City, Penn.

That the lubricator works when the pump is running with the ¾-in. valve wide open and using valve *C* as a throttle shows the trouble. The lubricator being of the single-connection type, caused to act by the vacuum produced which draws the oil from the lubricator.

The friction met with at valve *B* when using pump *A* and throttling with valve *C* is enough to prevent the feeding of oil. The pipe between the lubricator and the pump should not contain a valve unless of large size, so as to reduce the friction to a minimum. If a ¾-in. stop cock is used in place of the valve and kept open while the pump *A* is running, no trouble will be experienced.

EDWARD L. JOHNSON.

Brooklyn, N. Y.

Bending Sand-Filled Pipe

While reading the article under the above heading in the Apr. 23 issue, noticed that the blacksmith was so badly scared that he said he would never again bend a piece of pipe he could not look through. The accident should not stop him from filling the pipe with dry sand as it will never blow out.

I have had several years' experience in pipe bending, and when making right angle and U-bends we always filled the pipe with dry sand. In some shops the filings and turnings from the machine shop are added to the sand, which should be good and "sharp," such as is used in the manufacture of cement.

Good bends, however, may be made without the use of sand or other material for filling the pipe. By flattening the pipe at the point where the bend is desired and pulling against the bend, a satisfactory job may be made. The use of sand, however, is to be recommended as the sand retains the heat, thus enabling even good-sized bends to be made in one heat. U-bends may be made between rollers without using sand, and if care is exercised they will turn out perfect.

J. H. DIEHL.

Philadelphia, Penn.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Carbonic Acid Refrigerating System

What are the objections to a carbonic-acid refrigerating system?

A. A. B.

The extremely high condenser and suction pressures required to operate them; the difficulty in keeping the system tight on account of the high pressure necessary; the very cold cooling and condensing water required to obtain good efficiency of operation. The power required to do certain refrigerating work increases rapidly with an increase in condenser pressure. A leak in the system is not easily detected as carbonic acid is odorless; it does not give any warning of its presence when it is escaping, and persons walking into a room filled with it have been overcome by the gas.

Corliss Engine Valves

Are the steam valves open, with the wristplate central, of a tandem-compound Corliss engine?

J. K.

If the valve-gear of each cylinder is controlled by a single eccentric, the steam valves should be closed, the lap varying with the size of the cylinder. If the exhaust and steam valves are controlled by separate eccentrics, the steam valves will be open with the wristplate central, and have a lead or negative lap of $\frac{1}{32}$ to $\frac{1}{16}$ in., depending on the size of the cylinder.

Negative Lap

How much negative lap should the steam valves of a double-eccentric Corliss engine have with the wristplate central?

A. D. K.

There should be a lead or negative lap of $\frac{1}{32}$.

Coking Arch and Dutch Oven

Under what conditions is a coking arch used in a boiler furnace, and what is a dutch oven?

J. P.

A coking arch is used with a mechanical stoker and is of such length that the coal is completely coked by the time the fuel has passed the arch. A dutch oven is a furnace in which the flame of the burning gases is confined in an oven; that is, a brick inclosure of such size and shape that no flame will touch any metal parts of the boiler and hence be chilled before combustion is complete.

Inclined Arches

What is the advantage of an inclined arch with a mechanical stoker?

K. J.

An inclined arch sloping in the direction of the travel of the stoker has the advantage over a straight arch in that the heat is reflected back on the green fuel and aids combustion.

Horse Power of a Pelton Wheel

What is the horsepower of a 10½-ft. Pelton wheel, supplied with water under an effective head of 80 ft. through two nozzles each 7 in. diameter?

F. W. K.

A formula for the horsepower of a Pelton wheel is

$$Hp. = 0.00496\, Ecnd^2 \sqrt{h^3}$$

Where

E = Efficiency of the wheel;
c = Coefficient of discharge from nozzle;
n = Number of nozzles of equal diameter;
d = Diameter of jet in inches;
h = Effective head in feet.

Assuming the efficiency E to be 80 per cent, and the coefficient $c = 0.9$, the formula will be reduced to

$$Hp. = 0.00357\, nd^2 \sqrt{h^3}$$

Substituting figures, the formula would be expressed thus

$$Hp. = 0.00357 \times 2 \times 7^2 \sqrt{80^3} = 250.3$$

Furnace Arches

What is the greatest span and rise of furnace arches?

P. K.

The span of the arches is approximately the width of the boiler firebox and is limited therefore only by the size of the unit; the rise is approximately 1 in. per foot of space.

Mercurial Barometer

Is the vacuum in the upper end of a mercurial barometer perfect?

C. A.

There is not an absolutely perfect vacuum in the end of a mercurial barometer. There is present the vapor of mercury under the pressure and temperature. It is practically impossible to prevent some gas being occluded in the mercury and released into the highly vacuous space, even if the mercury is boiled.

Load on Staybolts

What is the load per square inch on each staybolt of a firebox boiler, the distance between the centers of the stays being 4 in. and the staybolts 1 in. in diameter and the pressure 160 lb. per square inch?

P. R.

To find the load on each staybolt in pounds, multiply the vertical pitch by the horizontal pitch and subtract the area of one stay. Multiply the difference by the pressure per square inch, and divide the result by the area of the stay. In this case it would be

$$\frac{(4 \times 4 - 0.7854) \times 160}{0.7854} = 3099\ lb.$$

Safe and Bursting Speed of Flywheels

How are the bursting and safe speeds of flywheels calculated?

P. S.

As little or no assistance is rendered by the flywheel arms in resisting the centrifugal force which tends to disrupt the rim of an ordinary flywheel, the calculations are based solely on the strength of the rim. The resistance of the rim is considered with reference to its tensile strength in the direction of the circumference and is based upon the tensile strength of its weakest part, whether that may be at a point where its segments are held together or at a section of continuous portion of rim.

To determine the number of revolutions per minute at which a flywheel will burst, divide the tensile strength in pounds of the weakest part of the rim (taken circumferentially) by its weight in pounds, and divide this quotient by the mean radius of the rim in feet; obtain the square root of the last quotient and multiply by 135.7.

To determine the safe speed, use 42.88 for a multiplier in place of 135.7. Assuming the weight of cast iron to be 0.26 lb. per cubic inch and its safe tensile strength 1000 lb. per square inch of section, an application of the rule to cast-iron flywheels having solid rims, will show that they may be considered safe against bursting from centrifugal force up to a rim speed of 6085 ft. per minute.

Study Questions

This Week's Questions
Last Week's Answers

6. What size wire is required to carry a direct current of 320 amperes 700 ft. with a 3 per cent. drop in voltage?

7. A stone is projected down a well with a velocity of 50 ft. per second. How many seconds will it take to reach the bottom if the well is 493 ft. deep, neglecting air resistance?

8. The storekeeper of a large street railway found that in each of its three plants they had on hand the same quantity of lubricating oil and the same number of barrels. There were 21 barrels in all, of which seven were full, seven half empty and seven empty. How were they divided among the three plants?

9. The lever of a lever safety valve is 42 in. long from the fulcrum to the end and 4 in. from the fulcrum to the center of the valve stem. The valve is 3 in. in diameter and with its stem weighs 7 lb. The effect of the weight of the lever is a downward pressure of 14 lb. at its free end. The weight weighs 30 lb. At what pressure per square inch will the valve blow off when the weight is 15 in. from the free end of the lever?

10. What should be the diameter of a cast-iron water main, one mile long, laid without sudden bends or elbows; to deliver water at the rate of 50,000 gal. in ten hours, from a reservoir having 200 ft. elevation above the point of discharge with a discharging pressure of 45 lb. per square inch?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

1. The mean forward pressure per pound of absolute initial pressure for 5 per cent. clearance and one-quarter cut-off is 0.6258 of the initial pressure as found by the formula $P_m = 1 + log._E R\ (f + c) - c$ where P_m = the mean forward pressure; $log._E R$ = the hyperbolic logarithm of the ratio of expansion; f = fraction of stroke completed at cutoff and c = the clearance expressed as a fraction of the cylinder displacement. The absolute initial pressure is 85 + 14.7 = 99.7 lb. The mean forward pressure is then 99.7 × 0.6258 = 62.39 lb. Since the exhaust pressure is 15 lb. absolute, the m.e.p. of the ideal diagram would be 62.39 — 15 = 47.39 lb. As the actual and ideal diagrams will be of the same length, their areas will be proportional to their mean effective pressure. The m.e.p. of the actual diagram being given as 44.6 lb., the percentage of the ideal diagram covered by the actual diagram, or the diagram factor is $\frac{44.6 \times 100}{47.39} = 94.1$ per cent.

*Tables for the value of Pm for different clearances and points of cutoff are given in Low's "Steam Engine Indicator," page 115.

2. The man who can do the work in eight days does ⅛ in one day. Similarly the others do $\frac{1}{12}$ and $\frac{1}{10}$ in one day and all three together can do $\frac{1}{8} + \frac{1}{12} + \frac{1}{10} = \frac{37}{120}$ in one day and finish the work in $\frac{120}{37} = 3\frac{9}{37}$ days.

3. To raise a pound of water from 32 deg. to the temperature of steam at 120 lb. absolute requires 312.3 B.t.u. To evaporate the whole pound would require 877.2 B.t.u. But 2 per cent. of it remains as water and to evaporate the other 98 per cent. would require 0.98 × 877.2 = 859.656 B.t.u. Each pound of the wet steam then carries 312.3 + 859.656 = 1172 B.t.u. into the engine measured from 32 deg. One horsepower-hour is equivalent to 2545 B.t.u. The engine uses 16 lb. of steam per horsepower-hour. Of the heat contained in each pound of steam 2545 ÷ 16 = 159 B.t.u. are converted into work. This leaves 1172 — 159 = 1013 B.t.u. to be rejected to the condenser. In the condenser this will be reduced to water at 100 deg., which contains 67.97 B.t.u. per lb. The difference 1013 — 67.97 = 945 B.t.u. to be absorbed by the cooling water.

One pound of water at 100 deg. contains 67.97 and at 60 deg. 28.08 B.t.u. above 32 deg. Each pound of water in being raised from 60 to 100 deg. would absorb practically 40 B.t.u.

It would therefore take

$$945 \div 40 = 23.6\ lb.$$

of water per pound of steam.

4. The pipe being horizontal and open at the end the only pressure required is that necessary to overcome the friction of the water in the pipe. The answer is most quickly found from tables for friction heads, as given in handbooks. For example, Ellis & Howland's tables in "Kent's Pocketbook" give the friction head for 200 gal. discharged per minute through a 4-in. pipe as 28.09 ft. per 1000 ft. of length. For a 400-ft. length this will be ⅖ of 28.09 or 11.236 ft., which, reduced to pounds, is 11.236 × 0.433 = 4.865 lb. The result can also be obtained from Cox's formula

$$H = \frac{L}{d} \frac{4\,V^2 + 5\,V - 2}{1200}$$

where H = the friction head; L = the length of pipe in feet; V = the velocity of the water in feet per second, and d = the diameter of the pipe in inches, after finding the velocity of the water by dividing the volume of water in cubic feet passed per second, by the area of the pipe in square feet, i.e., the volume, 200 gal. per minute = $\frac{200}{60}$ = 3⅓ gal. per second = $\frac{3.6666}{7.4805}$ = 0.49 cu.ft. per second. The area of the pipe equals

$$\left(\frac{4}{12}\right)^2 \cdot \frac{3.14159}{144} = 0.0874\ sq.ft.$$

$$Velocity = \frac{volume}{area} = \frac{0.49}{0.0874} = 5.6\ ft.\ per\ sec.$$

The other values required in the formula were given in the problem.

5. One equation for the volume of a spherical segment is

$$V = \tfrac{1}{6}\,\pi\,a^2\,(3R - 2a)$$

where V = the volume; π = the constant 3.14159; a = the altitude or height of the segment, and R = the radius of the sphere. Given V = 29.3216 cu.ft. and R = 6 ft. and solving the above equation for a, it will be found that the height of the segment is 2 ft. Knowing a and R, the radius of the base of the segment V may be determined from the equation

$$r^2 = 2Ra - a^2 \quad r^2 = \sqrt{20} = 4.47\ ft.$$

Colliery Boiler Explodes

A boiler exploded recently at the plant of the Rock Cannel Coal Co., of Cook County, W. Va., killing one and seriously injuring several employees, including the engineer. The boiler was of the locomotive type carrying 125 lb., and is said never to have been inspected.

President of N. A. S. E. on Tour

On Wednesday evening, May 8, Illinois Association No. 1, of the National Association of Stationary Engineers, Chicago, entertained National President Edward H. Kearney, who is officially visiting in the Middle West. Many enthusiastic members from No. 1 and sister associations welcomed him.

National Secretary Fred Raven, past president of No. 1, introduced President Kearney, who spoke of his efforts and aims as executive head of the largest operating engineers' association in the world. He said that the association was spending more money now than ever before in promotion of its educational work; that the problem of extending educational opportunity to all is complex, as the size and needs of the different associations are various. He also felt encouraged by the support his educational policy is receiving throughout the organization.

National Vice-president John McGrath spoke briefly of his hearty accord with President Kearney's policies and his hope that succeeding national presidents will recognize the wisdom of carrying them even further.

Past National President John P. Beckerleg, who recently celebrated his seventy-ninth birthday and mentally is one of the youngest of the national officers,

spoke reminiscently of the modest beginnings of the N. A. S. E. 30 years ago and optimistically of its splendid future. Mr. Beckerleg was the organization's second national president.

Past Presidents Charles Naylor and John Lane followed, paying tribute to President Kearney's ability and energy. Among the other speakers were W. L. Parker, state deputy for Illinois; W. G. Lighty, president of Illinois No. 1; George Noward, past president Illinois No. 2; W. Q. Barnhart, president Illinois No. 28; J. H. Cappers, past president Illinois No. 32; Herman Tavernier, president Illinois No. 38; Alfred Johnson, past national trustee; Harry Ashton, president National Exhibitors' Association, and Thomas Andresen, past president of Illinois No. 38.

Fred Hickey, of the Dearborn Drug & Chemical Co., sang witty songs and gave a humorous monologue.

Illinois No. 1 has been conducting a members' contest for the best paper on "Cost of Operation of an Office Building Plant." Prizes were awarded as follows: First prize, $25, Jonathan R. Moore; second to sixth prizes, $5 each, A. E. Christophersen, Lawrence McNeill, R. G. Allison, Jacob Reitz, A. S. Harrington.

President Kearney's tour included Detroit, Milwaukee, Des Moines, Kansas City and Cincinnati. At Kansas City he transacted preliminary business in connection with the coming national convention in September.

International Accident Prevention Convention

The new American idea of the safety engineer, an accident prevention specialist, will be brought to the notice of world industrialists at an international safety congress to be held in Milan, Italy, for five days, beginning May 27, 1912. This congress, the first of its kind of international scope, will be for the purpose of setting in motion a world-wide movement for the conservation of human life in industry.

The American Museum of Safety, 29 West Thirty-ninth St., is making preparations so that the United States will be well represented. An American national committee has been selected by the museum to coöperate with the international body and to promote the American ideas and views at the congress. Dr. W. H. Tolman, director of the American Museum of Safety, and other members of the committee will attend.

The following papers will be read: "The Safety Engineer on a Large Transportation System," by Dr. W. H. Tolman; "How the New York Edison Safeguards the Lives and Limbs of Its Employees," by Arthur Williams; "The Work of the Safety Committee of the United States Steel Corporation"; "Safeguarding the Traveling Public and Protecting the Employees of the Electric Street Railway Association"; "Proper Illumination and Accident Prevention," by J. V. Lansingh, president of the Illuminating Engineering Society.

SOCIETY NOTES

The Pennsylvania State Association, N. A. S. E., will hold its annual convention in Du Bois on Friday and Saturday, June 7 and 8. The exhibit will be of high standard and the attendance of delegates is expected to be unusually large. A lively program of entertainment is being arranged by the local committee.

The National Association of Stationary Engineers of New Jersey will hold its twenty-first annual convention at Newark, May 30 to June 2. In consequence of the overcrowded condition of the hall occupied by the 1911 convention, the local committee has this year engaged Kruger's Auditorium, the largest hall in the state. The Auditorium has been arranged with every possible convenience for the exhibitor, and the mechanical display promises to be larger and better than ever before. The delegates will hold their meetings in the same building. On Saturday, June 1, a banquet and entertainment will be given, and several other features of entertainment will be provided.

The Connecticut State Association of the N. A. S. E. will hold its annual convention at Bridgeport, Conn., on Friday and Saturday, June 28 and 29. There will be a full representation of delegates, and the mechanical display will be large. The Board of Trade and the Business Men's and Manufacturers' Association of the city are aiding the local committee in making the convention a success. During the business session many interesting papers will be read, and lectures of importance to the engineer will be given. The entertainment program includes trips to the various industrial plants in Bridgeport, the main feature being a sail on Long Island Sound. The national president and many persons prominent in the association have promised to be in attendance.

The seventeenth annual convention of the New York State Association of the National Association of Stationary Engineers will be held at Yonkers, July 14 to 16, with headquarters at the Getty House. The Armory has been secured for the mechanical exhibition, and the display promises to be elaborate. The drill hall has been fitted up with booths and arrangements made for the accommodation of 100 exhibits, nearly all of which have been taken. The business meetings of the delegates will be held in the hall adjoining the exhibit. On Friday evening there will be a banquet, to which several prominent speakers have been invited as well as some good entertainers. There will be many other interesting entertainment features, among them being a visit to the Otis Elevator plant where lunch will be served. This convention will be the largest in the history of the New York State Association, and great credit is due the local committee for its earnest work.

OBITUARY

Samuel A. Tinkham

On May 8, Samuel A. Tinkham, for many years chief engineer of the Joy Line steamer "Tennessee," died suddenly in the engine room while the steamer was at her dock in Providence, R. I. He was widely known among marine engineers along the coast.

Mr. Tinkham was about 60 years old and lived at Fairhaven, Mass., where a brother and a daughter reside.

Otto Jahn

Otto Jahn, chief engineer of the Vilter Manufacturing Co., of Milwaukee, Wis., for 23 years, died Apr. 29 at his home, 2431 Cold Spring Ave., after a short illness.

Mr. Jahn was born in Luetjenburg, Schleswig-Holstein, 59 years ago, and studied at the Gymnasium in Kiel, and later on at the Royal Institute of Technology in Chemnitz, Saxony. After serving in the army, he was graduated from the Polytechnic Institute, Berlin. In 1879 he came to America and entered the employ of the Scranton Locomotive Works, Scranton, Penn.

For six years Mr. Jahn was superintendent of the plant of the Morton Frog & Crossing Works, in Chicago, and then took a responsible position in the mining department of the Fraser & Chalmers Co., now the Chicago works of the Allis-Chalmers Co. He came to Milwaukee 2½ years later, and in April, 1889, entered the employ of the Vilter Manufacturing Co. as chief engineer in charge of construction and design, in which capacity he served until a few days before his death.

During his long connection with this company the business developed from an output of a few plants to over 150 plants yearly, many of them of large capacity. The successful application of refrigeration to many diversified industries is due in a large measure to his extensive experience in this field and a careful study of the problems involved.

Mr. Jahn was a member of the Turnverein Milwaukee, of the Association of Graduate German Students and of the German Engineers Society. He is survived by his wife and daughter, a sister, Mrs. C. Warns, and a brother, Dr. Ludwig Jahn, both of whom live in Germany.

A Confession

We are guilty! And have decided to make a clean breast of it—here it is.

1. Any concern that does business under any system of protection is accepting graft—but all of 'em want to keep it, and yell murder when it is proposed to reduce the protection by a penny.

2. The one-cent-a-pound postage on newspapers is a form of protection—it is government pap, a subsidy—the Postmaster General says so, and that that is the reason of the deficit. Never mind the law. Never mind the hundreds of businesses founded on that law. Upset 'em.

3. Canada carries her newspaper mail free in a forty-mile radius and anywhere in the Dominion for a quarter of a cent a pound—and her post office department shows a big profit. But, of course, our politician ridden department can't do that—who expects it to?

4. This concern sends practically all its papers through the mail at second class rates.

5. We acknowledge receipt of letters and envelope fillers from our advertisers containing the assertion that if some League can force the newspapers and magazines to pay two cents a pound, that "we, the people" can have one cent letter postage, but—

6. The newspapers are fighting this tooth and nail (sic).

7. *We wish to announce here and now that this change would save us money, and we would welcome it like finding a pocket book.*

8. We confess that when the government made its first investigation some four years ago, our President proposed a plan of charging the present rate of one-cent-a-pound for carriage alone and a fraction of a cent *per copy* for delivery. This would have more than doubled the revenue from mail matter of the second class and made the papers receiving service pay for it.

9. We confess that later on he proposed a uniform rate for all *printed matter*, fully routed and delivered to a post office, as required of newspapers.

10. We confess that none of these plans were very popular with publishers, or at Washington.

11. We confess that the object of these suggestions to increase our own expenses was for the purpose of taking the censorship off publications, and putting publishing on a par with other commercial enterprises.

12. We confess that all civilized countries carry all forms of disseminating information at the lowest possible rate.

13. We confess that the technical press of America is the best in the world and admired and respected in every foreign country except the District of Columbia.

14. We confess that this same technical press is expected to defend the sacred cow of protection set up before the high altar of the industry which each paper represents, and

15. To be glad that there are more foreign than American papers entered at the New York Post Office *for transportation through our mails at one cent a pound*, and

16. Notice. Members of the League need not write on the margin of their yowls that if it wasn't for *us*, "they" (whoever that may be) would have one cent letter postage—*we are right with you*, and will petition Uncle Sam to make that trade at once.

17. But, we hang our heads in shame when this great Country of ours confesses that it can not conduct its post office department as well as Canada for instance. No wonder the Canucks wouldn't "reciprocit" with us. They have us skinned on a lot of things, and it looks as if the distribution of information essential to the whole people is one of the things.

THE OLD MAN.

POWER

Vol. 35 NEW YORK, MAY 28, 1912 No. 22

To The College Grad.

We had a wise editorial in our issue of May 14, entitled "The Technical Graduate and the Power Plant." If you have not read it yet, do so. Its ideas are those of one of your own professors of engineering, whose opinion you should accept. The subject seemed so very important and timely that we were constrained to add these words emphasizing the advantages to the young mechanical engineering graduate in starting his career in the power plant.

Apparently you feel you must get into an engineering office at once and be ready to start designing some important work as soon as your ability is recognized. It is a serious mistake to try to begin in the designing end before first acquiring valuable operating experience while you are young and can afford to do so. After you have spent a few months or a year each as regulator, operator, water-tender, oiler, watch engineer, etc., you can bring far greater judgment to bear when you finally do get into the designing office and you will rise faster than the man whose only foundation is his school training.

The pay of the beginner in the power house is as good as, or even slightly better than, that of the beginner in the drafting room. The difference lies in the hours and the work. In the drafting room the hours are from 9 a.m. to 5 p.m. or at the outside 8:30 a.m. to 5:30 p.m. Here you may wear good clothes and white collars and revel in a sense of dignity that some think belongs to the handling of drawing instruments and being surrounded by imposing-looking blueprints, slide-rule, etc.

On the other hand, as a novice in the operating department you must perform long hours of manual work probably in less comfortable surroundings and certainly in less polite garb. You deal in such commonplace materials as cotton waste, oil and grease, even dust and dirt. Many times a day you must swallow your pride and perform some humble task at the none too polite order of a superior, but such work ultimately brings its compensation in the form of useful knowledge of operating problems and ability to judge the merits of new schemes from the practical operating viewpoint, lack of which has led many a man to commit follies which lived long to discredit his ability.

To the largest success, both practical and theoretical knowledge are necessary. Until you recognize this fact the practical engineer will have the advantage of you. Your theoretical knowledge he may get from books and at home. His practical knowledge you can never get that way.

Take it from the professor and the present sermonizer—when you doff the "cap and gown," don the "cap and overalls."

Rope Brakes, Construction and Design

By Julian C. Smallwood*

Description of several arrangements of rope brakes with directions for using them and for calculating the horsepower from the scale reading.

Also how to design a brake to absorb a given horsepower; the size of rope, number of turns, and whether to employ water cooling.

*Associate professor of experimental engineering, Syracuse University.

For some reason, the rope brake has not found as much favor as other forms of absorption dynamometer. In spite of this, however, it has certain advantages which, in some cases, make it preferable to the wooden-block prony brake. The principal one is that it may be easily made, a rope brake often being put together in a few minutes with only such materials as are at hand. Furthermore, it is inexpensive, light and portable, and will cover a larger range of load than the wooden-block prony brake, which fact makes it desirable when necessary to test an engine at various outputs. It gives a more uniform frictional resistance to be overcome by the engine and this in spite of lubrication being unnecessary.

More accurate measurements can therefore be made as the chattering due to lack of uniform resistance is avoided. In the usual forms it is not necessary to measure the unbalanced weight as is the case with the prony brake, and this makes for ease and accuracy. It is more readily applied to vertical shafts and one brake is adaptable to several sizes of flywheel.

The only disadvantages of the rope brake are such as may be avoided by proper design. There is a tendency for the rope to stretch in operation, and such stretching may decrease the frictional resistance of the brake and therefore the output of the engine. This difficulty, however, is avoided in two of the forms about to be described. Also, in some designs, it is necessary to take readings of two brake forces instead of one to determine the brake horsepower; but this inconvenience may also be avoided.

The simplest form of rope brake consists of a rope wrapped around a flywheel or pulley on the shaft the power of which is to be measured, as in Fig. 1. The ends of the rope are attached to some stationary apparatus through spring balances for measuring the pull which is created by previously tightening the rope. Because of the friction between the rope and the flywheel, the motion of the flywheel tends to make the left-hand end of the rope tighter and the right-hand end more slack. Hence, there will be a greater tension in the left-hand than in the right-hand end, and the difference between these tensions will be the net force overcome by the engine. To vary this force, it is necessary only to change the initial tightness of the rope.

This force applied at the rim of the wheel multiplied by the circumference and the number of revolutions per minute gives the number of foot-pounds developed per minute, and this divided by 33,000, the brake horsepower. Since the circumference is the diameter (or twice the radius) multiplied by 3.1416, the horsepower becomes

$$B.h.p. = \frac{2 \times radius \times 3.1416 \times force \times r.p.m}{33{,}000}$$

$$B.h.p. = 0.00019 \times radius \times r.p.m. \times force$$

That is, to find the brake horsepower: *Multiply the radius of the brake in feet by the revolutions per minute and by* 0.00019. *Multiply the number so found by the net force in pounds indicated by the scale or scales and the product will be the brake horsepower.*

Strictly speaking, the radius of the brake should be taken as the radius of the wheel plus the radius of the rope, but, in most cases, the radius of the wheel only is sufficiently accurate.

It is seen that since only the difference between the rope tensions is needed it is not necessary to measure them separately. Separate measurement, however, allows a form of brake which is easier to make, although it is not so convenient to use.

The form of brake shown in Fig. 1 may be applied to a vertical shaft, and the rope tensions are measured by the spring balances *S S*, the turnbuckle being provided to vary the tensions. This brake is suitable for small torques (that is, where the mechanical power divided by the revolutions per minute is small) and high rotative speeds such as yielded by an electric motor or a steam turbine. For large torques, at least one of the spring balances must be replaced by a measuring device having a larger capacity. Fig. 2 shows how this may be done when the plane of the pulley is horizontal. The force is transmitted through a wooden bellcrank to the pedestal which rests on the platform of a platform scales. The bellcrank should be hinged carefully to avoid friction at this point.

The force on the slacker side of the rope is generally small and therefore a spring balance is sufficient to measure it. The use of two spring balances, even with small torques, is objectionable as they are apt to allow bodily motion of the rope. This may result in chattering.

In Fig. 3 one of the balances and the turnbuckle are dispensed with by using dead weights on the rope extremity having the greater tension. The horsepower is varied by adding or removing these weights. This brake has the advantage that an increase of length of the rope does not affect the brake load since such an increase would be accompanied by a lowering of the weights only, the tensions remaining the same. The weights should be provided with a stop *P*, to prevent an accidentally excessive friction from raising or throwing them. The spring balance of Fig. 3 may be replaced by another but smaller set of dead weights. Then, when weight is added to one side, enough should also be added to the other to produce equilibrium. It is an awkward matter, however, to do this nicely as unavailable subdivisions of weights are at times required.

In POWER of September 19, 1911, page 442, the author described a rope brake similar to that shown in Fig. 3, except that a single heavy weight is used on the left side and a set of small weights on the right. The heavy weight rests on a platform scales so that the rope tension on this side is the difference between the platform-scale reading and the weight on the scales. The brake load is varied by changing the weights on the right side. This device has been found very satisfactory in that fine regulation may be secured with very uniform resistance. In this case the net force overcome at the rim of the flywheel is the heavy weight minus the sum of the scale reading and the small weights.

In some cases there is not room to hang weights from the flywheel, in which case a brake of the type shown in Fig. 4 is applicable. The heavier tension is measured by the platform scales, being transmitted from the rope end by a lever *L*, having equal arms. The fulcrum is preferably a triangular piece of steel in order to avoid friction, but may be a pin, as shown. The handwheel is used to make fine adjustments of the load by tightening the rope; the turnbuckle may be used for coarse adjustments.

In volume XVI of the *Transactions* of the American Society of Mechanical Engineers is described a rope brake with which the difference of tensions is measured directly; that is, only one scale reading is necessary. Fig. 5 is a modified form of this brake. The ends of the rope are attached to the cross pieces *C C* of a wooden frame which rests on a platform scales. If a handwheel is not conveniently obtained, a nut will serve the purpose for adjusting the rope tensions. It is important that the stops

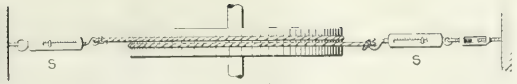


Fig. 1

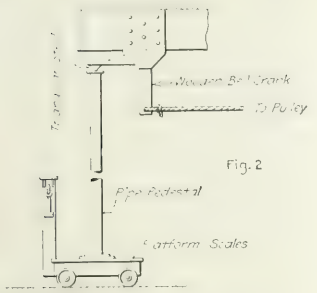


Fig. 2

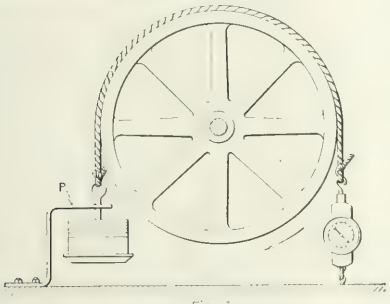


Fig. 3

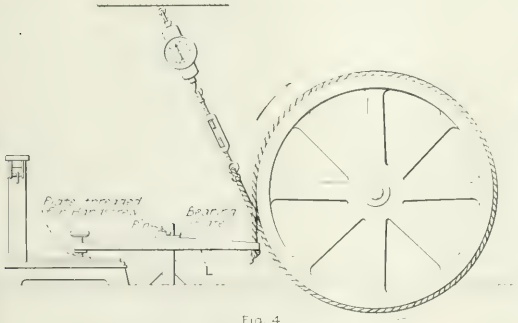


Fig. 4

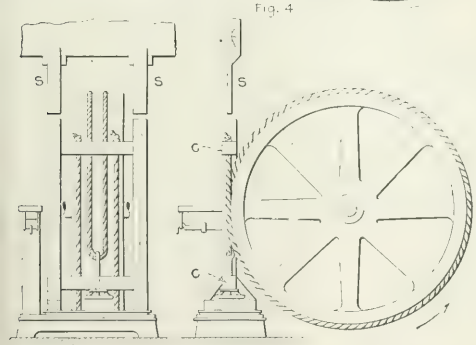


Fig. 5

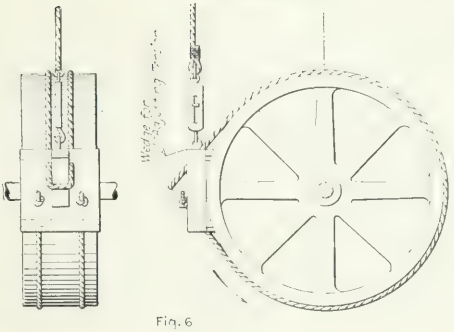


Fig. 6

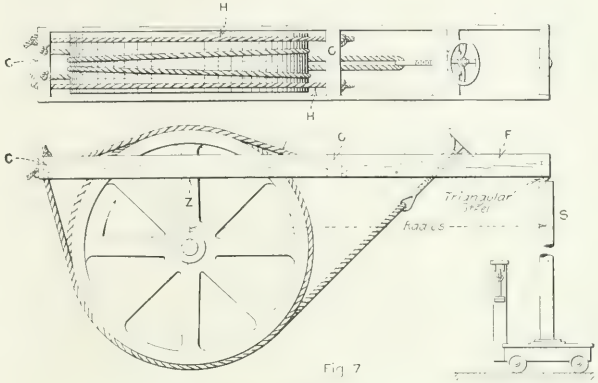


Fig. 7

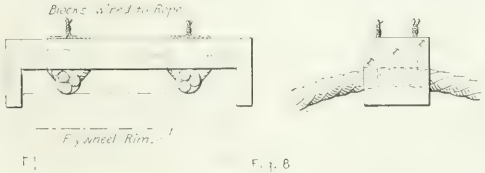


Fig. 8

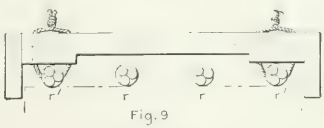


Fig. 9

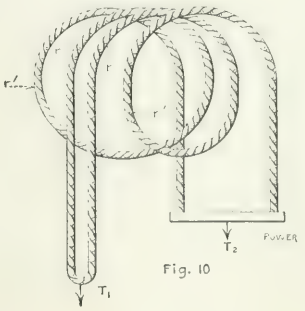


Fig. 10

VARIOUS TYPES OF ROPE BRAKES

S S be provided to prevent the lifting of the framework, if it is possible for the engine to reverse. The author has on several occasions used this type of rope brake and found it very satisfactory. It should be noted that the weight of the frame should be carefully determined with the ropes detached, and this weight subtracted from the readings taken during operation.

Fig. 6 shows another brake of this type, suitable for small torques and high rotative speeds. The wedge is used to adjust the tensions, and the net tension is measured by a single spring balance. The radius to be used in calculating the horsepower should be measured as shown. The weight of the block, wedge, etc., should be subtracted from the scale readings, if the brake is held by the balance from above, and added to them if below.

In Fig. 7 is shown a brake by which the thrust on the scales is kept low by the use of a brake arm *F*, the ends of the rope being fastened to the cross pieces *C C*. The arm is hung on the flywheel by the short ropes *H H*, and the thrust is measured by a platform scales through a strut *S*. The radius for use in the horsepower formula is as shown. This brake has the advantage of fitting various sizes of flywheel with a change only in the length of the rope.

The weight of this brake is not balanced; that is, some of it is recorded on the platform scales. This must be determined and subtracted from the gross readings of the scales in operation. To find the unbalanced weight, the brake may be removed from the flywheel, its strut end supported as in use and its flywheel end on a knife edge or small pin placed at the point *Z* which, when the brake is adjusted, is just over the center of the shaft. The rope should be entirely disengaged. With this arrangement the scales will indicate the unbalanced weight of the brake.

Water Cooling

Generally, if a brake load is to be carried by an engine for any length of time, some provision must be made to withdraw the heat generated by the friction to prevent the rope charring or catching fire. This is usually accomplished by feeding water into the trough formed by internal flanges on the rim of the flywheel or pulley to which the brake is attached. The water is flattened against the inside of the rim and retained there by centrifugal force. Usually, another pipe with a scoop-like entrance is arranged to withdraw the heated water. Very often, however, this is unnecessary, since, if boiling is allowed, the water supply may be adjusted so as to equal the evaporation; that is, evaporation disposes of the water without allowing the rope to get too hot. If the flywheel is not too small for the power absorbed, this means of disposal will be found effective.

Air radiation sometimes provides ample cooling when the brake pulley is large in comparison to the power absorbed. This is particularly the case when the brake load is to be applied for a short time only.

Some safeguard is needed generally to prevent the rope from slipping off the pulley. The rope, like a belt, tends to run to the center of a crowned pulley, and where only a single turn or half turn is used on such a pulley no other provision need be made to keep it on. For large powers, where a number of ropes are necessary, it is well to provide some other means to accomplish this purpose. An externally flanged pulley will do this simply; if one is not available, blocks like that shown in Fig. 8 may be fitted to the rope. This shows a block suitable to a single turn, or less, of double rope. Fig. 9 shows a block which may be used with a rope arrangement such as is represented diagrammatically by Fig. 10. This permits opposite motion of the ropes *r r* from that of *r' r'* when the whole rope stretches. Enough of these blocks should be fastened to the rope to hold it securely to the wheel.

Except for light powers, it is better to use double rope, as this provides more surface to resist wear without altering the desired relation of the tensions. Fig. 10 shows 1½ turns of double rope whereby the relative values of the tensions on the tighter and slacker sides are the same as would be obtained by a single rope wound in 1½ turns.

It is preferable to attach the device for adjusting the rope tension to that end upon which the tension is smaller, namely, the end which points in the direction of rotation. The preference is made because, the force being less, it requires less effort to change it.

If two spring balances are used the springs should be of different stiffnesses; otherwise their vibrations are likely to synchronize and a chattering will result.

The Design of Rope Brakes

The design is usually adapted to the size of pulley or flywheel at hand. It is first necessary to ascertain if the available pulley is large enough, if water cooling will be required, or if air cooling will suffice. For this information the following rule may be used:

Multiply the width of the wheel face in inches by the velocity of the wheel rim in feet per minute and divide by the horsepower to be absorbed. If the quotient exceeds 900, *air cooling will do. If it lies between* 400 *and* 900, *the brake should be water cooled. If it is less than* 400, *a larger wheel should be used.*

This rule is due to Flather (see Flather's "Dynamometers") and is intended to proportion the parts of wooden block prony brakes. The rubbing surfaces of this type of brake are much larger than those of the rope dynamometer; nevertheless, within the author experience, the rule also applies to the latter type. This is probably due to the fact that the radiating surfaces in the two types are about the same. With the rope brake, the heat generated by the friction is quickly transferred from the limited contact surface to the adjacent parts of the rim, where it finds ample opportunity for radiation.

In order to determine the size and number of ropes to use, there must first be found the net force which the brake must handle; that is, the force which will be indicated upon the scale, or the difference of the forces if two scales are used. To find this:

Multiply the horsepower by 5250 *and divide the product by the radius of the wheel in feet and the number of revolutions per minute. The final quotient will be the net tension.*

It is well here to emphasize the meanings of the terms "net force" and "rope tensions." The net force is the effective force overcome by the engine. The rope tensions are the forces existing in the ends of the rope and their difference equals the net force. The tension in the tight end of the rope is therefore greater than the net force, and the rope must be strong enough to carry this tension.

The relative values of the rope tensions depend upon the number of turns around the wheel and the condition of the rubbing surfaces. Table 1 gives quantities that will reduce the calculations for design in the general case.

TABLE 1

Number of Turns of Rope	Ratio of Greater Tension to Net Force	Ratio of Greater to Lesser Tension
½	1.40	3.51
¾	1.18	6.59
1	1.09	12.3
1¼	1.05	23.2
1½	1.02	43.4

The data apply to well worn manila rope on smooth pulleys. This table gives the ratios of the brake forces for various numbers of rope turns. From it is seen, for instance, that with a one-half turn, the greater rope tension is 1.09 times the net force and 3.51 times the lesser tension. It follows that to find the greatest tension resisted by the rope

Multiply the net force by the figure in the second column of Table 1, *corresponding to the number of turns in the first column.*

Using this result, a suitable rope to carry the load may be selected from Table 2. This gives the working strength of good manila rope of three strands. These values agree well with the data given by Flather, Reuleaux and the American Manufacturing Company, a factor of safety of about five being used. The rope is listed according to its largest diameter.

TABLE 2

Diameter, Inches	Working Strength, Pounds
¼	300
⅜	450
½	700
⅝	1000
1	1300
1⅛	1700
1¼	2100

Take, as an example, the design of a rope brake of the type shown in Fig. 5 for a 50-horsepower engine having a flywheel 5 feet in diameter and an 8-inch face, and running at 200 revolutions per minute. The velocity of the rim is then

$$3.1416 \times 5 \times 200 = 3141 \text{ feet per minute}$$

Using the rule for cooling,

$$\frac{\text{Width of face} \times \text{velocity}}{\text{Horsepower}} = \frac{8 \times 3141}{50} = 503$$

Since 503 lies between 400 and 900, water cooling is necessary. Using the rule for the net force,

$$\text{Net force} = \frac{5250 \times \text{horsepower}}{\text{Radius} \times \text{r.p.m.}} =$$

$$\frac{5250 \times 50}{2.5 \times 200} = 525 \text{ pounds}$$

If one turn of rope is used, then, from Table 1 the ratio of the greater tension to the net force is 1.09. Therefore,

$$\text{Greater rope tension} = 1.09 \times 525 = 572 \text{ pounds}$$

From Table 2 it is seen that two ½-inch ropes would carry this load satisfactorily, since the working strength would be twice 300 pounds. But, to resist wear, it is better to use rope at least ⅝ inch in diameter except in the case of small powers. For this brake one ¾-inch rope would do, but two ⅝-inch ropes are selected for convenience in fastening the blocks.

For a brake of the type shown in Fig. 7, the calculation of the rope size is the same as that just given, but the thrust on the brake scales will be less than the difference between the rope tensions in the inverse proportion of the distances of these forces from the shaft center. For instance, if a brake arm of 7.5 feet were used with the brake in the preceding example, the thrust on the scales would be

$$525 \times \frac{2.5}{7.5} = 175 \text{ pounds}$$

If the tensions are to be measured separately as in the type of the brake shown in Fig. 4, the capacity of the apparatus measuring the greater tension for the engine in the example must be at least 572 pounds. If a scales of this capacity is not available, the arms of the lever may be made of unequal length to reduce the force measured. The value of the lesser tension is found by dividing the greater tension by the ratio given in the third column of Table 1, thus,

$$\text{Lesser tension} = \frac{572}{12.3} = 46.5 \text{ pounds}$$

which determines the capacity of the spring balance shown in Fig. 4.

The third column of Table 1 is compiled from the well known belt formula which is also applicable to ropes; that is:

Ratio of tensions equals the number whose logarithm is 2.73 times the product of the coefficient of friction and the number of turns.

For the coefficient of friction, Unwin gives the value 0.28 for ropes on flat pulleys, and Flather uses a number somewhat higher. These figures, however, apply to the conditions of rope drive. Experiments made by the author to determine the coefficient of friction of well worn rope on a smooth pulley indicate that it is a quantity which varies markedly with the velocity between the rubbing surfaces and with the rope tensions. From these experiments it appears that an average value of the quantity is 0.4, and this value was assumed in compiling the table.

The second column of the table was found by the relation:

Ratio of greater tension to net force equals ratio of rope tensions divided by the ratio of rope tensions minus one.

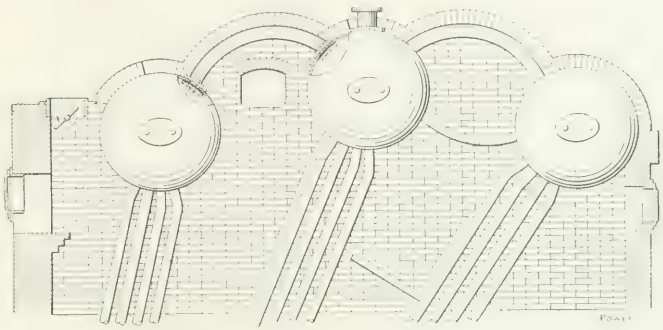
These formulas for finding the ratios of the brake forces will enable one to design a brake the conditions of which are not included in Table 1, as, for instance, would be the case if the wheel-rim surface were rough enough to make reasonable the assumption of a higher value of the coefficient of friction than 0.4.

In conclusion, it may be well to emphasize the fact that the rope brake, in general, is readily adaptable to given conditions. A selection from the types described may be governed entirely by the consideration of the materials at hand; or, if a superior product is wanted, the rope brake may be designed to be quite equal to, and often better, than other dynamometers in refinement, accuracy, convenience and cost.

It is pointed out by James Innes, in a paper, "Marine Boilers," read before the Institute of Marine Engineers, that there have been but few cases of late years where it has been necessary to repair the shell plating of boilers, although during the old compound-engine days it was common. This is because, in almost all cases, the shell plates have been made of steel of large size, and have been riveted by hydraulic pressure. Not only have the shell joints—the longitudinal and circumferential seams—been properly designed, but the former have been properly placed well up on the boiler side. In the eighties it was no uncommon thing to find longitudinal seams at the bottom center line, and in not a few instances has it been necessary to fit new butt straps or rerivet the old straps owing to leakage.

Emergency Boiler Repair

In a certain boiler plant it was found necessary to remove one of the equalizing pipes running from the rear to the center drum. After the equalizing pipe had been removed and the workmen were ready to put in a new one it was discovered that those on hand were too small in diameter to fit the hole in the steam drum. The engineer therefore decided to plug the holes.



How the Holes in the Drums Were Covered

Two blank pieces of cast iron were obtained which were an inch larger in diameter than the hole in the drum. A shingle was cut so that one end was of the same curvature as the inside of the steam drum. This was used as a pattern for the second gage. The inside plate was ground and filed until the second gage made a perfect fit with the outside surface of the blank piece.

The outside blank flange was fitted to the outside diameter of the drum in the same way, a bolt hole was drilled through both pieces, and after a solid-rubber gasket had been put on the inner blank flange a nut was placed on the threaded end of the bolt and the whole tightened up. Both holes in the drums were treated in the same manner, after which the boiler was operated until a proper size of equalizing pipe was obtained.

Operating Records of a Small Plant

By O. Monnett

Some actual figures from a plant serving a group of buildings with light, heat, power, hot water, etc.

During the heating season the cost of current amounts simply to the fixed charges against the electrical apparatus as all of the exhaust steam is used for heating.

The furnishing of light, heat and power from a central plant to a group of buildings involves a number of factors, all of which must be considered before a comprehensive plan can be worked out. When these buildings, as in the case of the Moody Bible Institute of Chicago, represent a number of different, though closely allied interests, so that the record of the service rendered to each by the power plant must be kept separately, each bearing its proportionate share of the expense, the book-keeping problem involved necessitates an accurate account of operating costs and a clear knowledge of all operating conditions.

The power plant, Figs. 1 and 2, of the institute is located in the basement of what is known as the old building, which, as shown in Fig. 3, is about the center of the property; there are walks and alleys on all sides of the building so that the engine and boiler rooms receive plenty of light and air.

Equipment

The main pieces of equipment are three 72-in. by 18-ft., horizontal, return-tubular boilers, with Burke furnaces; one 75-kw. and one 150-kw. Westinghouse generator, direct-connected to Ball engines. These are both three-wire machines and are provided with balance coils. There are also located in the engine room two boiler-feed pumps, two vacuum pumps, a large house pump, a feed-water heater and a hot-water service heater.

Two electric passenger elevators, an ice machine and various ventilating fans throughout the building furnish the power load, and to keep the cost data as accurately as possible the plant was equipped with the necessary measuring devices to check the daily operation in all of the various departments.

Besides a hot-water meter in the feed-water line, the boilers are fitted with a CO_2 recorder, so arranged that a reading can be taken from any boiler at any time, a direct-reading pyrometer and a differential draft gage.

A wagon scale is installed in the alley and all coal received is weighed. The engineer's gage board is provided with a recording steam gage and an integrating wattmeter on the switchboard checks the electrical output.

Heating Arrangement

The first problem was to take care of the heating of the eight buildings, new and old, from one central heating plant, and at the same time provide some means of measuring the amount of steam used in each building so that a charge could be made. The two new buildings, located as shown in Fig. 1, have Webster vacuum-heating systems, and one of the old buildings was changed over from a gravity-return to the vacuum system. Three of the old buildings, equipped with ordinary gravity systems, were disconnected from their old independent boilers and connected to the new system. The equipment in the Moody Church consists of a blast coil system and fan designed for steam at 50 lb. pressure. This was connected to the central plant by means of special supply line, carrying steam at 60 lb. pressure.

Meters

In each of the buildings comprising the group a dip meter was installed to measure the condensation from the radiators. It was found that the hot return water working under a vacuum was accompanied by a large amount of vapor which was not accounted for by the meters. To make these meters read correctly an ordinary double-pipe condenser coil was connected into the return line between the heating system and the meter to sufficiently cool the return water to prevent vaporization.

Traps were placed between the heating returns and the dip meters on the gravity systems, and by this means it was possible to condense the steam. Readings of these meters are made on the first of each month by the operating engineer.

Each of the buildings is also provided with a house-type wattmeter on the electrical-supply feeders and they are read on the first of each month. From these readings the various departments are charged for the light and heat used.

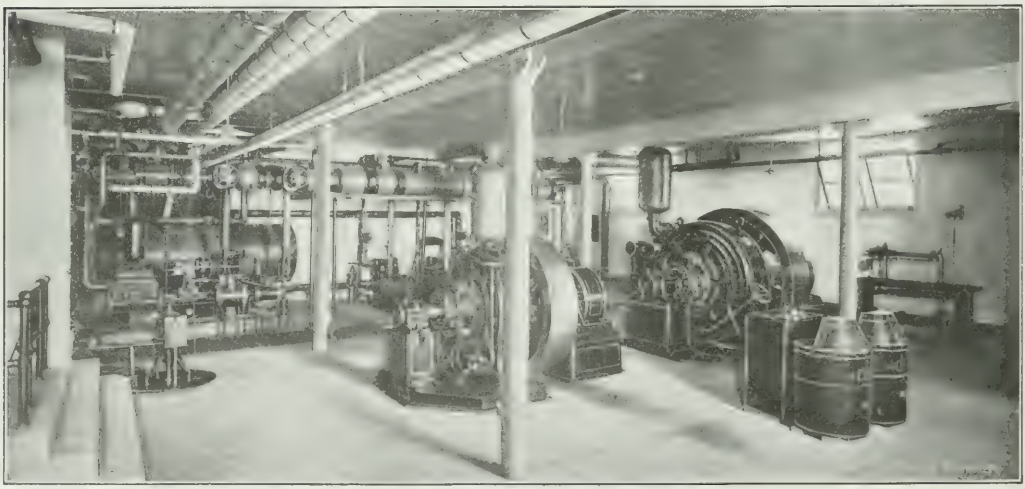


Fig. 1. Engine Room of the Moody Bible Institute, Chicago

As a check on the heating system and to be able to account for the total water used in the plant, the feed water is measured by a hot-water meter at the boilers. During the winter months, when there is no steam going to the atmosphere, the difference between the total reading of the dip meters and the boiler feed-water meter is charged to the heating of hot water for the buildings, the feed-water heater, vacuum cleaner and to steam used in the kitchen for cooling and dish-washing. This amounts to about 30 per cent. of the total steam used for all purposes during the winter months.

TABLE 2. MONTHLY STATEMENT OF HEATING, LIGHTING AND POWER

Date March 1, 1911

Labor			
Chief engineer		$110 00	
First engineer		85 00	
Second engineer		75 00	
First fireman		68 00	
Second fireman		30 00	
Third fireman		30 00	
General helper			$398 00
	Lb.		
Supplies			
Coal, on hand	110,000	$168.85	
Coal bought during month	664,200	1019.55	
Total	120,000	1188.40	
Coal on hand	654,200	184.20	
Net		1004.20	
Lubricants		0.95	
Boiler compound			
Packing			
Waste		0.25	
Miscellaneous			
			$1005.40
General expenses			
Fixed charges, 1 per cent. per annum on $22,350		$223 50	
Repairs		30 50	
Hauling ashes		78 00	
Miscellaneous			$332.00
Total			$1735.40

Boiler Plant

Total run during month	672 hr.
Total water evaporated in boilers	3,869,190 lb.
Total coal consumed	654,100 lb.
Total ashes removed	
Percentage of ashes removed to coal consumed	
Pounds of water evaporated per pound of coal consumed	5.9 lb.
Average horsepower in boilers	169
Cost of coal evaporating 1000 pounds of water	
Cost of producing 1000 pounds of steam	

Engine and Generator Plant

Total run during month	672 hr.
Electrical output in kilowatt-hours	15,600 kw.-hr.
Average rate of current consumption in all buildings	23 kw.
Consumption of steam per kw.-hr.	
Cost per kw.-hr.	

Water-meter Reading

	Present	Last	Net
Men's building, 153, city water			64,486 cu.ft.

Steam-meter Readings

	Present	Last	Net
Men's building, 152, returns			370,000 lb.
Men's building, 153, returns			725,000 lb.
Women's building, 812, returns			100,500 lb.
Women's building, 830, returns			480,000 lb.
B.I.C.A. building, 826, returns			106,000 lb.
Church and Y. P. building, returns			157,000 lb.
Total			1,938,500 lb.

Electric Meter Readings

	Present	Last	Net
Men's building, 152, ammeter			2,435 kw.-hr.
Men's building, 153, ammeter			4,930 kw.-hr.
Women's building, 830, ammeter			4,149 kw.-hr.
B.I.C.A. building, 826, ammeter			298 kw.-hr.
Church and Y.P. building, ammeter			1,622 kw.-hr.
Elevator, men's building, ammeter			kw.-hr.
Elevator, women's building, ammeter			kw.-hr.
Kitchen, ammeter			94 kw.-hr.
Street lights and boiler room			1,400 kw.-hr.
Total			14,928 kw.-hr.
Vacuum cleaner run			196 hr.

Signed: ..... Engineer

Distribution of Costs

Under the foregoing conditions, with the steam heating approximately 70 per cent. of the total boiler load, the electricity generated is considered practically as a byproduct. Even in the summer months, live steam is required for the vacuum cleaner, kitchens, laundry, etc., in the main buildings and the ventilating-fan engine in the church, while the exhaust from the electrical units heats the feed water and the hot water for the buildings.

Table 1 gives a good idea of the general costs and power requirements, one month's record being taken for each of the four seasons of the year. The coal consumption shown is the total cost used for all purposes, including firing up, banking, etc.; in quality it is equal to No. 4 or No. 5 Illinois screenings, which run rather high in ash.

Monthly statements are made by the engineer on the form shown in Fig. 4, the figures being for March, 1911. From these data it is possible to figure the cost of any item desired.

Two methods of arriving at the electrical cost may be used. If the total cost per month is $1735.40 and the output is 14,928 kilowatt-hours, then the cost per kilowatt-hour is 11.6c. This, of course, is unjust, as all of the heating, ventilating, cooking, elevator service, etc., should be considered. As a matter of fact, there would be just as many boilers in use, as much coal burned and supervision necessary if the electrical plant were not installed.

The proper method of figuring the unit electrical cost in this instance, therefore, is to charge the electrical output with the fixed charges on the investment in the apparatus necessary to generate the current. This amounts to 12 per cent. per annum on $10,000, or $100 per month, making the cost 0.66c. per kilowatt-hour for the month of March, 1911, with the engines used as reducing valves on the heating system.

As a basis for arriving at the cost of

TABLE 1 OPERATING DATA OF MOODY BIBLE INSTITUTE

	Costs					Lb. Water Evap.	Lb. Coal Burned	Kw.-hr. Generated
	Labor	Coal	Supplies	Miscellaneous	Total			
Winter month	$370 50	$1067 75	$14 67	$44 00	$1496 92	4,170,720	695,100	14,220
Spring month	428 25	462 62	79 77	141 75	1112 39	2,032,000	450,000	6,510
Summer month	320 00	245 27	72 46	45 05	682 78	967,000	156,000	5,300
Fall month	360 06	396 25	35.08	42 87	834 26	1,599,000	262,000	9,055

FIG. 2. THE BOILER EQUIPMENT

1000 lb. of steam it is figured that if the charges against the electrical equipment amount to $100 per month, the total monthly cost minus $100 gives the cost of the steam generated. This, in the case of March, 1911, is $1635.40, and as 3,869,190 lb. of water were evaporated in the boilers for this month, the cost per 1000 lb. is 42.3c.

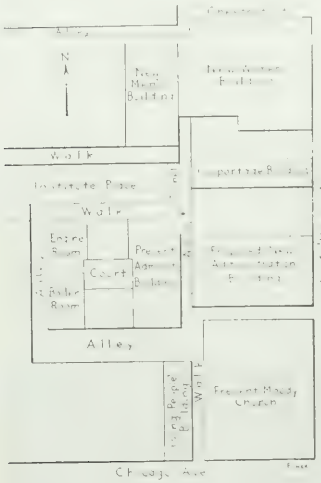


FIG. 3. PLAT OF BUILDINGS

A nominal charge is made against each building for the current used and a rate per 1000 gal. of condensation in the heating system is charged such as will enable the total cost of the power plant to be divided among the several buildings according to the service rendered; with the data available this becomes a simple matter.

W. A. Blonck & Co., consulting engineers of Chicago, designed and installed the plant.

Boiler Waters

On the evening of Apr. 30, W. A. Converse, chemical director of the Dearborn Drug & Chemical Works, of Chicago, Ill., lectured on boiler waters before the Modern Science Club at its quarters, 125 South Elliott Pl., Brooklyn, N. Y.

The lecture was illustrated by many stereopticon views of analysis charts, corroded tubes and scale formations; views of the Dearborn Laboratories and of natural lime formations in Yellowstone National Park. The demonstrations given of methods of analyzing feed waters were very thorough as the apparatus and paraphernalia used by Mr. Converse were equal to that found in many laboratories.

After dwelling on the constituents of water and briefly defining a few chemical terms, the speaker said that the carbonates of lime were supposed by many engineers to cause only a scale formation in the boiler. He contended that serious cases of foaming were sometimes due to their presence in the water. The dissolving effect of alkaline substances in boiler water on the gaskets and packing used on the boilers was well brought out. Mr. Converse stated that Eastern engineers are favored with extraordinarily good feed water as compared with Western districts. He illustrated by analysis charts some Western waters which showed that they contain very little carbonates of lime, while they are high in sulphates of lime and therefore dangerous on account of the rapid formation of exceedingly hard scale.

A case was cited where there were 27 lb. of lime substance deposited every 24 hours in a boiler located in a Western state. The deleterious action of sulphuric acid when present in feed water was explained as due to its concentration. With feed water high in sulphuric acid, the water is evaporated while the acid remains in the boiler. As the volume of water evaporated becomes greater, the amount of acid also increases to a point where corrosion is very rapid, owing to the affinity of sulphuric acid for iron.

Analysis cards of other Western waters showed a high percentage of sodium and potassium sulphates, the action of which is severe on boiler plates. These substances are not precipitated and are therefore difficult to deal with; the only cure for such water is to distill it before its use. The corrosive action of magnesia salts, said Mr. Converse, is due to the salts being affected by high steam pressures and thereby giving off muriatic-acid fumes which not only affect the boiler plates but are injurious to the steam piping and engine cylinders as the acid is carried by the steam used in them. The causes of foaming and priming were also clearly explained.

The speaker cautioned against unwise legislation governing the use of feed waters, stating that in many Western districts it was possible to obtain only one grade of water, and that often this water was highly deleterious for boiler purposes, but as better water was not available it was a case of tolerating an unavoidable evil.

Analysis cards of waters taken from the East and Middle West districts were then explained. A recent analysis of Croton water showed that it contained hard scale-forming agents, but could be considered a fairly good water. Brooklyn city water was also said to be fair. The water from Clifton, Staten Island, the speaker said, was low in carbonates of lime, but as a water containing corrosive agents it was one of the worst he had met with in 20 years' experience in analyzing and treating boiler waters. The action of this water is to pit and corrode, forming very deep grooves above the water line and a hard scale below the water line.

The water of South River, N. J., was considered remarkable, inasmuch as it contained an exceedingly high percentage of sulphuric acid, while there was no apparent reason for its presence in the water. The sulphates were also high; consequently it was a vicious water for boiler purposes. Monongahela River water at Pittsburg also proved high in sulphuric acid. The water at Atlantic City was shown to be high in silica. Satilla River water, taken from Waycross, Ga., contained dangerous corrosive agents; the galvanic action set up by this water was said to be one of its characteristic features.

To illustrate how river water varies in substances injurious to boilers, the speaker showed several analysis cards of Mississippi River water the samples of which were taken from points between Minneapolis and New Orleans. It was surprising how the percentage of impurities increased at each southerly point. The waters of the Great Lakes are also similar in their variation of impurities.

Views of lime formations were next shown; among them that of an internal feed pipe, on the end of which was an enbow. The lime had accumulated on the fitting until it appeared nearly three times its original size; the opening had been reduced to about one-fifth its original diameter.

The lecture was well attended, and Mr. Converse was highly successful in reducing the technical matter to ordinary and understandable terms.

Oil Burning Plant at Irish Shipyard

To be independent of coal as a fuel, four large boilers at Harland & Wolff's Shipbuilding Works on Queens Island, Belfast, Ireland, have been adapted for oil fuel. Using coal for fuel, one of these boilers evaporates 16,000 lb. of water an hour and the other three 12,000 lb. each, and with liquid fuel they will generate 4000 hp. per hour. The work of installation is so simple that it can be carried on without letting the steam out of the boilers.

The steam-jet system is used. The oil enters the boiler through a branch pipe and is given a whirling motion by the prolonged spiral stem of the valve spindle, the amount of oil being governed by a handwheel at the end of the spindle. The steam enters at another valve and passes through slots in the cylindrical part of the cone. All the oil passing through the burner is thus steam jacketed. One or two men can attend to a dozen boilers burning liquid fuel.

Notes on Steam Boiler Efficiency*

By Edward A. Uehling

Boilers under test conditions compared with those under ordinary working conditions. The relation of draft and the percentage of CO_2 to efficiency.

*From a paper read before the Master Mechanics Association of America, at Boston, on Apr. 26.

Fifty years ago a steam engine that consumed less than 40 lb. of steam per horsepower-hour was quite the exception. Twenty-five years ago 30 lb. was accepted as good practice. Today a steam consumption above 20 lb. is considered unsatisfactory, and in exceptional cases a steam consumption as low as 10 lb. per horsepower-hour has been reached.

The best average boiler efficiency fifty years ago was probably close on to 60 per cent; 25 years ago it was about 60 per cent., and today the average boiler efficiency still hangs close to 60 per cent. Thus while the steam engine has been so improved that a given amount of steam will produce nearly three times the power obtainable 50 years ago, the steam boiler continues to waste 40 per cent. of the heat energy contained in the fuel. There are several reasons why this is so:

To begin with, the steam boiler (including its setting) because of the simplicity of its function, had been developed into a far more perfect apparatus for the purpose of generating steam 50 years ago than was the steam engine of that time. Later, however, thorough investigations of the properties of steam were carried on by scientists, who formulated the laws of expansion, thereby not only revealing the great wastefulness of the then existing steam engine, but at the same time pointing out the upper limits possible to attain. Based on these revelations of science, inventive genius and mechanical skill, in combination with practical experience, wrought the great improvements embodied in the many types of engines of today, including the steam turbine.

The principal reason for the slow progress in the economical operation of the steam boiler is due largely to the fact that it is of necessity a rough and uncouth apparatus, placed in dirty, dingy surroundings, generally indifferent and often inadequately housed.

Brawn and muscle are considered the principal requirements in a boiler attendant. As a rule, neither compensation nor environment is calculated to attract the more intelligent from among the men available, and perhaps there is not one fireman in a thousand who has any conception of the chemical reactions that constitute the process of combustion.

The steam engine, on the other hand, is a highly finished machine, housed in well lighted and well appointed quarters; therefore commanding and receiving close attention. Furthermore, it is attended by high-class men, trained by education and long experience, who understand its mechanism and mode of operation.

Again, in the steam engine, although it is a complex mechanism as compared with the steam boiler, the regulations and adjustments necessary to maintain maximum efficiency are exceedingly simple in comparison to what is required to attain and maintain the highest boiler efficiency.

A steam engine correctly designed and properly constructed, accurately adjusted and adapted to the work to be performed, will give maximum economy. The speed is uniform and the steam used is automatically regulated to suit the load. Certain definitely fixed and automatic adjustments have been found to give maximum efficiency; the attendant has only to maintain these adjustments to insure efficiency.

The efficiency of the steam generator depends on far more complex conditions, many of which are not only beyond control, but are continually changing. Some of them are atmospheric conditions, quality of the fuel and the condition of the boiler as to setting, dirty heating surface, air infiltration, draft, etc. The grates become choked with slate and clinker, obstructing the air passages and causing irregular flow, resulting in a deficiency of air in one place and an excess in another. Every one of these variables affects the efficiency of the boiler furnace. Furthermore, the required output, which varies in some plants between very wide limits, is an important factor. One is therefore forced to the conclusion that the lack of progress in boiler efficiency under actual operating conditions is not due to any want of improvements in design and construction of the present-day boiler and setting, though much remains to be desired, but that it is due almost entirely to insufficient knowledge of the conditions involved and consequent wasteful manipulation.

That this is true is proved by the fact that almost invariably official boiler tests, made by or under the direct supervision of experts, show from 10 to 20 per cent. greater efficiency than is obtained from the same boilers in everyday practice. This raises the question, can the high efficiency obtained by an expert be at least approximately maintained in everyday practice? If so, how can it be accomplished? What does the expert do to get his results?

He analyzes the coal for the purpose of ascertaining its heat value, and to find out how to burn it effectively. He brings with him one or more expert firemen, or selects the best available from the existing staff, and generally pays them extra to insure good work. He makes sure that the boiler is clean, inside and out, that the grate bars are whole and straight and suitable for the kind of coal to be burned. He sees to it that there are no cracks and crevices in the boiler wells and that the cleaning doors closed tight.

He is also assisted by a staff of trained observers. One keeps a careful record of the weight of coal fired; another accurately weighs or measures the feed water; a third analyzes the flue gas and notes its temperature, while the fourth ascertains the quality of the steam. Many other data are noted and recorded, all of which are necessary to enable the expert to calculate the efficiency of the boiler under test and to strike a heat balance. But with the exception of those appertaining to the composition and temperature of the flue gas, none of the data noted and recorded by the staff of assistants is of the least aid in attaining high efficiency. And since the two essential elements in the flue-gas records, CO_2 and temperature, can be autographically recorded and continuously indicated by appliances readily available at reasonable cost, an expert and a corps of assistants are not required to assure economic boiler operation in everyday practice.

Sifting the essentials from the non-essentials in the progam of the expert boiler testing, there are:

(1) Clean boilers; (2) tight settings; (3) skillful firing; (4) knowledge of the chemical composition and physical properties of the coal used; (5) furnace adapted to the fuel; (6) draft regulation; (7) continuous knowledge of the percentage of CO_2 contained in the flue gas, also its temperature at the point where it leaves the boiler.

The first five of these conditions essential to boiler efficiency should be quite self-evident.

1. As to clean boilers, it should not require the services of an expert to keep the boilers clean, yet a great deal of coal is wasted because of dirty and scaly heating surfaces.

2. Tight boiler settings are the exception rather than the rule. Should an expert and a staff of assistants be required to keep the settings tight? Certainly not. It is nevertheless a deplorable fact that air infiltration is one of the

most prolific causes of low boiler efficiency.

3. Every material change in the chemical and physical property of the coal requires a change in the method of firing, the frequency of cleaning the fire, the strength of draft, etc.; a correct knowledge of the chemical composition and physical poperties of coal used will, therefore, be of material assistance in maintaining high efficiency in everyday practice.

4. Regarding the furnace and grate bars, every steam engineer of experience knows that they must be adapted to the kind of coal available if good results are to be realized. It may and generally does require the service of a combustion expert to determine the grate and furnace construction best adapted to burning a given fuel; but when these conditions are once established there is no good reason why they should not be maintained.

5. Draft regulation is one of the most important factors and is probably the least understood. Draft, whether natural, forced or induced, is manifested by a difference in pressure. The effective draft is the difference in pressure between the air under the grate bars and that at the point of leaving the boiler. It may be considered as divided into two parts, namely, the furnace draft and the boiler draft. The former is the pressure difference between the ashpit and the furnace, and the latter is the pressure difference between the furnace and the uptake. The boiler draft varies directly with the volume of gas coming from the furnace; hence for the same rate of combustion it varies inversely as the percentage of CO_2 in the flue gas, and for the same percentage of CO_2 it varies directly as the rate of combustion.

The furnace draft depends on many things: the kind of coal, the rate of driving, the thickness of the fire, and its condition, the formation of clinker, etc., from all of which it is evident that the proper regulation of the draft requires close and intelligent observation and judgment.

6. Skillful firing and intelligent manipulation are therefore prime requisites in the economic operation of steam boilers, and that is why the expert, when he is conducting an efficiency test, is so particular in selecting his firemen. To overcome any errors in judgment on the part of the firemen, he resorts to analyzing the flue gases, which is the only correct and adequate method of controlling the process of combustion.

Maximum efficiency results when the necessary amount of fuel is completely burned with a minimum excess of air, and the flue gases leave the boiler with the lowest temperature consistent with the rate of driving. Without adequate means of knowing when this condition obtains, it is impossible for even the most expert fireman to maintain maximum efficiency.

Combustion experts when conducting efficiency tests generally determine the percentage of CO_2, CO and O; but for everyday practice it is necessary only to know the percentage of CO_2 and the temperature of the flue gas to be able to tell whether the boiler is being operated economically or wastefully, and to what extent heat is going to waste up the chimney.

Not less than 90 per cent. of the avoidable heat losses in the operation of steam boilers are due to excessive air supply, and since the percentage of CO_2 in the flue gas is a correct index of the excess of air it contains, an instrument that will continuously indicate and record this constituent is a most important if not an absolutely necessary factor in attaining and maintaining maximum boiler efficiency.

A continuous record of the temperature of the escaping flue gas, although less valuable for controlling the boiler operation, is nevertheless of great importance. The temperature when recorded simultaneously with the CO_2 will give most valuable information as to the condition and operation of a boiler. The temperature of the flue gases is but slightly affected by excess of air supplied to the furnace; hence cannot be directly controlled by the fireman. This depends on the ratio of the heating surface of the boiler to the grate area, on the condition of the heating surface, and on the rate of driving; also, the stack temperature is markedly affected by air infiltration, while an excess of air supplied to the furnace affects the stack temperature but slightly.

Thus it is seen that while the stack temperature alone may give very misleading information, in conjunction with a determination of the CO_2 very valuable information is had about the condition of the boiler itself as well as the boiler setting.

A draft gage applied to the furnace shows the resistance through the ashpit door, the grates, the ashbed and the fire. With a given effective draft, if the ashpit doors are partially closed the furnace draft is increased, but the rate of combustion is decreased. The same effect is produced by the accumulation of ashes, the formation of clinker and the caking of the coal. The furnace draft is thus increased by at least four distinct causes, all of which tend to check the rate of combustion. On the other hand, if the fire is sliced, the furnace draft is decreased and combustion is increased, and still more is this the case if the fire is cleaned. It is clear then that the readings of a draft gage in the furnace cannot be relied upon as an index to the rate of driving, much less to economical operation.

From the foregoing it would appear, first, that the chimney draft is affected favorably by wasteful boiler operation, due to high stack temperature, and unfavorably by wasteful operation, due to a low percentage of CO_2 in the flue gas; but that a knowledge of the chimney draft and temperature is of great value as a check on economic operation of a boiler plant; second, that the effective draft upon which depends the rate of combustion is itself dependent on the variable conditions of the furnace, that it cannot be relied on as a guide by which to regulate combustion; third, that furnace draft due to the ever changing conditions, must necessarily vary if a definite rate of combustion is to be maintained, and is, therefore, useless as a guide, but is of the greatest value as an index to the condition of the furnace, provided there is a true index to the rate of combustion. Fortunately, such an index can be made available.

From what has been said in the foregoing, it should appear evident that in order to attain and maintain high boiler efficiency it is necessary to employ scientific means for the purpose of gaining the information necessary to economical operation.

Damper and Fan Control

The method of controlling the damper and engine-driven forced-draft fan at the new power plant of the Hazard Manufacturing Co., Wilkes-Barre, Penn., is interesting and out of the ordinary.

The gases of combustion pass from the boiler to a rear connection, which is built at the back end of the boiler setting and is separated from the smoke flue built in the basement by a damper, which covers an opening 2 ft. 6 in. wide and extends the width of the boiler setting. Each boiler is equipped with this type of damper, so that any one boiler or all can be cut out from the smokestack connection.

Damper Arrangement

This damper is hinged on the inner edge and is provided with an eye-bolt, to which a chain is attached. The other end of the chain is connected to an adjustable rod that connects at the upper end with an arm which is secured to a shaft. This shaft is carried by hangers attached to the back wall of the boiler room and extends over the boiler settings. The general arrangement of the damper regulator, shaft connections and damper arrangement is shown in the accompanying illustration. The flat rod to which the chain from the damper is connected is made with suitable holes for adjustment, so that the damper can be regulated as to the amount of opening. As a means of counter-balancing the weight of each damper, pulleys which hang in a bracket attached to the brick wall

f the engine room serve as guides for veight cords, the several weights acting s a counter-balance to the several damp-rs.

The shaft in the boiler room is ar-anged with clutches, so that the arm to vhich the damper rod is connected can e disengaged from the shaft, and the other dampers operated independent of he cut-out damper. This permits of the damper being closed on any particular oiler when it is out of commission for epairs, etc.

The end of the damper shaft *D* is itted with an arm, to which is connected nother shaft *C* running at right angles o it, and which is in turn connected by similar arm to a shaft *A*. This shaft s hung to the wall just above the damper egulator in the pump room, and is con-ected by means of an arm and rod to an uxiliary cylinder, the plunger of which is operated by means of the damper egulator, the connection being as shown.

An ingenious method of determining the amount any damper is open has been arranged in the center-shaft *C*, in that the shaft is made in two sections and is drilled and tapped with a right- and left-hand thread.

Damper Inidcator

The rod, which is threaded and screws into the two ends of the shafts, is fitted with a wheel over which a chain is run. There is also an index pointer which, as the wheel is revolved by means of the chain, is moved either to the right or the left, according to the way the screw connection is revolved. This indicates on the scale placed above the indicator pointer the amount the damper is open. Thus, the fireman is in a position to know the open position of the dampers.

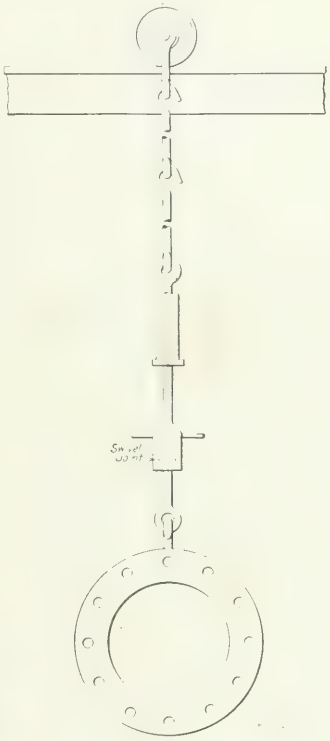
Fan Regulaton

The speed of the fan engine is also regulated by means of the damper regulator. Attached to the end of the shaft *A*, mounted above the damper regulator, is an arm that is connected with a lever *B*, pivoted as shown. To the end of this lever a rod is connected to which a turnbuckle has been fitted and which connects with the lever attached to a butterfly valve in the steam pipe leading to the cylinder of the fan engine.

When the steam pressure rises, the damper regulator causes the piston in the auxiliary cylinder to rise and thus actuates the adjustable cross shaft in the direction of the arrow, and this motion is communicated to the several dampers that are attached to the arms extending from the damper shaft and closes them. At the same time the end arm is moved upward, which will cause the end connected with the rod attached to the steam valve to move downward, and this closes the steam valve in the fan engine's steam pipe. Thus the draft is decreased in the furnace. A reversal of this operation opens the furnace to the natural draft in the chimney and at the same time the fan is speeded up. The arrangement is automatic and allows of close regulation as the amount of damper opening in the boiler smoke flue can be regulated for increased draft as the furnace fires become dirty.

Device for Removing Cylinder Heads

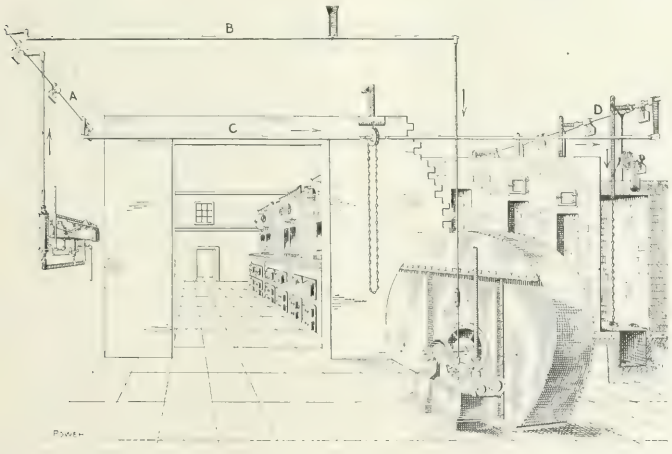
A device for removing the cylinder heads of hoisting engines is shown in the accompanying illustration. A T-rail is suspended by means of suitable hangers directly over the center of the cylinder. On this rail a pulley runs to which is fitted a yoke through which a pin passes, and upon which the pulley revolves. Secured to the lower side of the yoke is an iron rod which has a hook formed at one end and an eye at the other. A second similar rod is hooked to the first one, both of which are ¾ in. in diameter. To the eye of the second rod a turnbuckle arrangement is secured, which consists of a rod in which a threaded screw turns, the bottom end of the screw being drilled for a rod to turn the screw. The lower end of the screw is made with a swivel joint, as shown, and the lower end of the swivel is made with an eye. An auxiliary piece,



Cylinder Head Crane

with one end threaded, screws into a suitable hole in the cylinder head; the other end is made in the form of a U with a hole drilled through the open end so that a pin can be passed through it and the eye-screw.

As soon as the stud-bolt nuts have been removed, the swivel screw is tightened so that the weight of the cylinder is suspended by the arrangement when the whole is pushed back out of the way. This device is in use at the No. 2 colliery of the Susquehanna Coal Co., Nanticoke, Penn.



How the Regulator Controls the Damper and Fan Engine

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

Care and Management of Arc Lamps

1263. *What are the principal features to watch out for, to insure the proper operation of arc lamps?*

Assuming that the lamps are substantially made, their proper operation depends chiefly upon their being properly trimmed and correctly adjusted for the voltage at which they are designed to work.

1264. *In trimming an arc lamp, what are the important points to be observed?*

The use of proper carbons; removal of dirt from the clutch rod before pushing the rod up; placing the carbons so that they are vertically in line with each other and have enough vertical play to allow the lamp to pick up its arc; care to see that the carbon rods are firmly screwed into their holders; inner globes thoroughly cleaned, and if nicked or cracked so as to allow leakage of air, to be replaced by new globes; proper adjustment of the moving parts.

1265. *How should the carbons for inclosed arc lamps be selected and replaced?*

The carbons used should be of the best quality so that the quantity of deposited matter due to combustion will be as small as possible; they should be free from blisters, or roughness, hard spots and curves. A good guide as to the quality of the carbon is the appearance of the burned ends. Good carbons after being used present a dull surface, whereas the ends of hard carbons present a glossy pitted surface.

The trimming of inclosed arc lamps outdoors is facilitated by the trimmer taking with him a clear inner globe fitted with a lower carbon, to replace the old one in each lamp. It is necessary that the carbons be of the proper length. The upper carbons can be purchased of the desired length, but as the lower ones are often made up of the part left over from the upper carbon they should be cut to the proper length before being used for this purpose.

The proper operation of an inclosed arc lamp depends largely upon the free passage of the upper carbon through the cap of the inner globe. A ½-in. carbon should not be smaller than 0.5 in., nor larger than 0.52 in.; if smaller than 0.5 in., too much air will be admitted and the arc will flame.

1266. *What is the method of adjusting an arc lamp for the proper voltage?*

Before an arc lamp is installed, it should be adjusted for its proper arc voltage, which is usually 70 to 75 volts measured across the inclosed arc. The lamp should be burned about ten minutes before this measurement is taken so as to allow the carbons to assume their normal operating condition. Directions for adjusting the different makes of arc lamps vary considerably, so that no specific rules can be given to fit all cases. Directions, however, can be obtained from the manufacturers and they should be closely followed to secure satisfactory results. When adjustments are made without the use of a voltmeter, it is well to bear in mind that if the arc hisses it is too short, and if it flames badly it is too long. By watching the fluctuations of a voltmeter across the arc, as the carbons burn, a good idea may be formed of the smoothness with which the mechanism feeds.

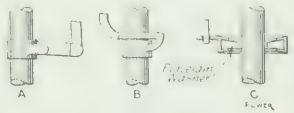


Fig. 417. Clutches

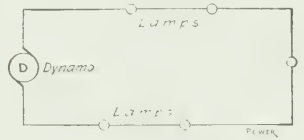


Fig. 418. Arc Lamps in Series

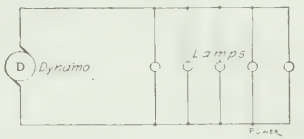


Fig. 419. Arc Lamps in Parallel

1267. *In case a lamp does not feed properly, where is the trouble usually found?*

In the dashpot or in the clutch, if the feed magnet is not burned out.

1268. *How may trouble in the dashpot be remedied?*

By wiping it clean with a dry cloth. If this does not clear the trouble, remove the dashpot and clean with gasoline the little check valve which has probably become stuck. Oil should never be used on it. If the valve is all right, the piston has probably worn loose, in which case a new one should be used.

Where arc lamps are used only occasionally, but must be kept ready for immediate use, the formation of scale inside the cylinder of the dashpot may be prevented by lighting the lamp for a minute or two every day. This daily action of the piston will scrape off the scale before it hardens sufficiently to interfere with the performance of the dashpot.

1269. *How may trouble in the clutch be remedied?*

In two-part metal clutches, such as shown at *A* and *B*, Fig. 417, dirt is liable to work in between the parts, which will then require cleaning. If, through the breaking of the upper carbon lead, the clutch is forced to carry the lamp current, it is liable to burn and bind the pivot pins. In all two-part metal clutches it is necessary to keep these pins loose to insure free operation. The porcelain washer clutch *C*, Fig. 417, is not subject to pin trouble, but may break if there is "jumping" of the carbons, in which case a new porcelain washer must be substituted.

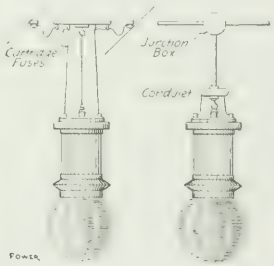


Fig. 420. Methods of Suspension

Connection of Arc Lamps in Circuit

1270. *How are arc lamps usually connected for street lighting?*

In series, as indicated in Fig. 418.

1271. *What are the current and the voltage conditions in a series circuit?*

The current through all the lamps is the same, assuming there is no leakage, and this current must be kept constant to obtain a steady illumination. If each lamp requires 75 volts, and there are fifty lamps in circuit, the generator must develop

$$50 \times 75 = 3750 \text{ volts}$$

plus the drop in the line.

In case any of the lamps are cut out by short-circuiting them, this being the only way in which lamps on a series system can be cut out without opening the circuit, it is evident that if the voltage remains constant the current will increase and perhaps burn out the lamps remaining in circuit. To prevent an increase of current under these conditions, an automatic regulator is used in connection with the dynamo.

1272. *How many lamps can be operated in a series circuit?*

About 100 lamps is the maximum that is considered practicable on a single circuit. This requires an e.m.f. of approximately 7500 volts.

1273. *How are arc lamps usually connected for interior lighting?*

In parallel across a constant-potential circuit, as shown in Fig. 419.

1274. *What are the voltage conditions in the multiple circuit?*

As the usual interior constant-potential circuit is operated at about 110 volts and the voltage across the inclosed arc is about 75, there remains about 35 volts to be taken up by the resistor in the direct-current lamp, or by the reactance in an alternating-current lamp. In an open-arc lamp, however, the voltage across the arc is only about 45 to 50, so that about 60 to 65 volts is wasted in dead resistance.

1275. *Is this greater loss of voltage in the open-arc lamp responsible for this lamp being superseded by the inclosed-arc lamp for multiple connection?*

Not entirely, because it is possible to operate two open-arc lamps in series across a 110-volt circuit, leaving only about 20 volts to be lost. The inclosed-arc lamp won out chiefly by reason of the slower combustion of the carbons and consequent saving in operating and maintenance cost, the softer light it gives, the better distribution of this light by means of the inner globe, the impossibility of heated carbon particles flying out and setting fire to inflammable material, and its quietness in operation.

1276. *How are indoor lamps suspended?*

Two approved methods of arc-lamp suspension are shown in Fig. 420; at the left, the method for exposed wiring, and at the right the method for concealed wiring. In addition to the insulator at the top of the lamp, there should be one in the suspension hook or wire to serve as further protection. Each lamp on a constant-potential circuit should be protected by an inclosed fuse, which may be of the cartridge type mounted above the lamp, as shown at the left of Fig. 420, or it may be of any other approved form connected in the lamp circuit and mounted at a distance from the lamp. This latter method is the more convenient one when concealed wiring is used and accounts for the absence of protective devices in the sketch at the right of Fig. 420, the conduit and junction box there shown being merely for convenience in wiring the lamp into circuit.

Electrically Operated Valves*

By H. M. Gassman

Valves of 24 in. diameter and larger are usually operated other than by hand for the reason that generally such valves must be closed in a very short time, which is impossible by hand operation, and also because such valves are frequently located in out-of-the-way places and are more conveniently controlled from some operating point more or less remote from the valves.

As large valves usually control very important service connections it is essential that the electrical equipment of these valves be dependable. To guard against failures the valves should be inspected and tried out regularly, particularly where they are likely to remain in one position for long periods.

The power required to open a valve is a maximum when starting the valve from its seat. After the gate has been opened, say one-fourth, comparatively little torque is required to complete the operation. The proportion of starting to running torque varies with the construction of the valve, the amount of corrosion and the condition of the valve seat. When closing hydraulic valves under pressure, the starting and running torques are comparatively small until the valve is about three-quarters closed. From that point on, the pressure on the gate increases approximately as a square of the decrease in the opening; consequently the torque at closing in such cases increases rapidly but does not reach the value of the starting torque required to open the valve under the same pressure conditions.

To overcome the sticking of the valve when it is to be opened, the drive is sometimes provided with a lost-motion device so as to give a hammer blow when starting the valve from its seat. With alternating-current motors such lost motion also allows the motor to develop a high speed and therefore a greater torque before starting the valve from its seat.

Unless some provision is made for limiting the torque of the motor or controlling the circuit when closing the valve, it is possible to jam and injure the mechanism of the valve, making further operation difficult. A slip gear cannot be used for this purpose as the slipping torque in opening will be practically the same as when closing, unless the gear be designed to act in the closing direction only.

Where compactness is a consideration the motor is rigidly attached direct to or on an extension of the valve casing. The motor and drive should be so arranged that there will be ample room for hand operation. An inclosed motor is preferred on account of exposure to dampness, water and flooding, inclosing being permissible without affecting the size of the motor, owing to the intermittent service. Terminals and wiring also must be protected against water and any mechanical injury which might result while repairs are being made to the valve.

A valve should not be overpowered by a motor for the reason that there is considerable risk of damaging the valve, and should not be underpowered because it increases the chance of failure when the conditions are extraordinary. The correct size of motor for the valve will vary with the duty and the general conditions under which the valve operates.

Where there is any choice of system the direct current is preferred in order to secure the advantages of a series-wound motor, giving a high starting torque and increased speed under light load. The commutator and brushs, however, are apt to give trouble in damp or wet locations. The alternating-current motor best adapted to valve operation is the squirrel-cage type, because of its simplicity. The motor should be designed with a high resistance rotor to increase the starting torque.

For equivalent performance—that is, the same assurance against failure of the motor to operate the valves—the alternating-current motor should be from 20 to 40 per cent. larger than the direct-current motor. In such applications motor efficiency does not enter, but operating efficiency does, and therefore it is economy to put on motors of greater capacity than would be actually required under ordinary conditions.

For remote control the ideal arrangement is one which permits of automatically starting and stopping the motor by simply throwing a switch or controller and one that makes it impossible to start the valve in the wrong direction and wreck some part of the valve or mechanism.

Where valves require direct-current motors larger than can be thrown directly across the line without resistance, such resistance should be designed to give the maximum torque required to open the valve and be retained permanently in circuit. As the motor speeds up due to a decrease in load, a step of sufficient resistance should be inserted in series with the motor to prevent excessive speed at light load, to slow down the motor as the torque increases near the closing point and to limit the torque finally should the valve seat itself before the motor is disconnected from the circuit. There are various schemes for obtaining this result with a two-point reversing drum controller or with a pilot switch control in combination with shunt- and series-wound contactors. In either case,

*From a paper delivered at the Pittsburg meeting of the American Institute of Electrical Engineers, Apr. 25-27.

limit switches should be provided at each end of the travel.

For alternating-current motors the same general scheme can be used as this type of motor will not increase in speed appreciably with change in load, but the resistance in the stator circuit will also have the effect of limiting the torque in closing the valve.

The limit switches can be designed to handle the motor current instead of the contactor exciting current. For small valves the limit switch is sometimes omitted and the motor allowed to increase its torque to the point of operating an overload circuit-breaker. Such an arrangement, however, is not foolproof in that it allows the operator to start the gate in the same direction at the end of its travel.

Detecting Defects in Armatures

By E. R. Parliman

In the Jan. 16 issue, Gordon Fox described a method for locating defects in direct-current armatures. In this connection he recommended the use of a U-shaped magnet for inducing a small electromotive force in the armature and then detecting the defects from bar to bar by means of a telephone receiver.

In the writer's opinion, the telephone test would be made much simpler by

Defective Coil Cut Out and Jumper Across Comutation Segments

using a battery and buzzer combination in place of the magnet. In making this test, place the terminals of the buzzer circuit over three bars on the commutator; then the terminals of the telephone receiver must bridge any two adjacent bars, between those in contact with the buzzer circuit. By revolving the armature, the receiver will record each separate coil in the armature winding.

There are three sources of trouble in a coil, a short-circuit, a ground and a coil having crossed wires. The indicator on the receiver with a short-circuit will sound dead when the receiver terminals bridge the commutator bar connected to the lead nearest to the short-circuit in the coil; while the bar connected to the other lead at commutator pitch distance will sound low.

The indications for a grounded coil will sound low on the bars connected with the defective coil and dead if one of the terminals of the buzzer circuit is placed on the armature shaft, while the other terminal remains on the armature commutator.

The best method, however, for testing out a ground is to place one terminal of a high potential circuit on the shaft while the other terminal is applied to each bar of the commutator successively. An arc will be produced when the second terminal makes contact with the bar connected to the grounded coil.

The indications for a crossed wire, commonly known as a crossed lead, will be very loud on the bars connected to the defective coil and low on the adjacent bars. A quick remedy for the short-circuited and grounded coils is to connect the defective parts with a "jumper"; for example, consider the four-pole, eleven-bar commutator armature shown in the illustration. Assume that in detecting the trouble, Nos. 1 and 11 sound dead, while bars Nos. 5, 6 and 7 sound low. Cut the lead *A* from bars 1 to 6 and *B* from bars 6 to 11, then cut the coil on the peripheral side, so that the coil, if grounded, will not become an isolated generator. The next step is to connect jumper *D* from bar No. 1 to bar No. 6 and jumper *E* from bar No. 6 to bar No. 11, so that the circuit will be complete.

This repair will not reduce the power to any great extent, as only two coils will be out of use, but if a number of coils were cut out the power would be reduced greatly.

This method in the second case might work temporarily, but the only systematic method to follow in such a case would be to install a new similar armature or rewind the old one.

LETTER

An Original Equalizing Connection

We recently installed a voltage-regulator panel, in addition to our switchboard, which called for the operation of the compound-wound exciters in parallel when both alternators are running or while changing over. The diagram in Fig. 1 shows practically how they were to be wired according to the blueprint.

After we had them wired as indicated, we started up exciter No. 2, and adjusted its voltage to equal the voltage of No. 1, which was running; on throwing in No. 2 exciter switch to put them in parallel, the polarity on No. 1 was reversed, "killing" the alternator excitation and putting out the lights all over town until we could throw in No. 2 alternator.

We had a double-pole double-throw switch connected as shown in Fig. 2 for charging batteries from either exciter, so by taking the positive lead and holding it on the positive terminal of No. 1 exciter, holding the negative lead on the negative terminal and closing the switch to No. 2 exciter for a few seconds, we got the polarity reversed back again.

We ran a couple of temporary wires from the lower contacts of the switch on the back of the board on No. 1 exciter to the alternator field rheostat, leaving the switch on No. 1 exciter out

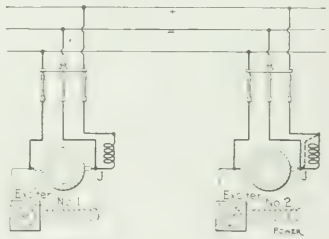


Fig. 1. Exciter Connections

to run the exciters separately and change the generators until we could locate the trouble.

On looking over one of my books I found a diagram that fitted our case and discovered that the equalizer wire should run from the junction of the series field terminal and the brush cable (*J*) to the middle pole of the switch. Instead of doing it that way, they ran a connection from the junction point *J* to the terminal of the series field winding, as shown by the dotted line in Fig. 1, on exciter No. 2, and left the middle pole of the switch free. I asked if that would not cut out the series field coil, and was assured they had tried that and it did not.

Fig. 2. Battery Connection

The manager took me over to exciter No. 1 that was running, and bridged across with a piece of wire as indicated by the dotted lines on No. 2.

"Now," he said, "you don't see the voltage vary any, do you?"

"Only about fifteen or twenty volts," I said.

After they had changed the connections to those shown by the solid lines everything was all right.

R. F. Calderwood.

Ida Grove, Iowa.

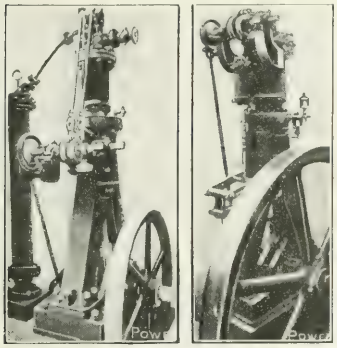
The diagram illustrating Mr. J. A. Croteau's letter on "Unexpected Wattmeter Readings" in the April 23 issue showed the two current transformers of wattmeter No. 2 on the same line. This is incorrect; instead, one transformer should be on the first line and the other on the second line.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Present Status of the Diesel Engine

Following his election to honorary membership in the American Society of Mechanical Engineers on Apr. 30, Dr. Rudolph Diesel, inventor of the well known engine bearing his name, delivered a lecture upon "The Present Status of the Diesel Engine." While the general scope of the lecture was along much the same lines as his London address of some weeks ago and many of the points



FIGS. 1 AND 2. FIRST AND SECOND EXPERIMENTAL DIESEL ENGINES

had been brought out from time to time in the technical press, still the paper covered in logical order the development of the Diesel engine from its inception to its present position as an important commercial factor. Furthermore, many points were brought out which are not of common knowledge, especially as applied to American practice.

FUEL

By way of introduction, Dr. Diesel pointed out the influence which his engine is having upon the coke and gas industries in Europe, the byproducts from these, such as tar and creosote oils as now produced, being especially adaptable for use in the Diesel engine. Of course this is not of so great importance in the United States on account of its richness in natural oil, but it is of utmost importance in those countries which have practically no oil production of their own. For instance, it is estimated that the tar production of Germany is sufficient for furnishing approximately 1¾ million hp. for 300 days of 10 hr. each per year.

Dr. Diesel also called attention to the fact that it is possible to use vegetable and animal oils in his engine, a fact not generally known. While this is insignificant at present, in the course of time it may play an important part.

EARLY HISTORY

Reverting to the early history of the engine, Dr. Diesel stated that the first attempt brought forth a vertical four-stroke-cycle engine constructed in 1893 (Fig. 1). This was fitted with a piston rod and external crosshead, the cylinder having no water jacket and the camshaft placed low with the valves actuated by means of long rods. There was no air-supply pump and the fuel was injected directly. This engine never ran, but at the first injection of fuel an explosion occurred and the indicator went to pieces. It served to prove, however, that it was possible to compress air so high that the fuel injected into it would ignite and burn.

The second engine (Fig. 2) had a water-jacketed cylinder and the camshaft was placed higher. Furthermore, it was fitted with an air pump. This engine also would not run.

Fig. 3 shows the first successful Diesel

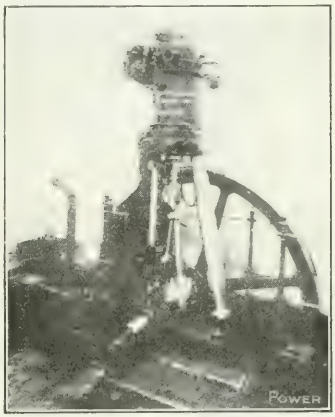


FIG. 3. FIRST SUCCESSFUL DIESEL ENGINE

engine. This was constructed at Augsburg in 1897 and developed 18 hp. It had the piston connected to an external crosshead and worked on the four-stroke cycle.

COMMERCIAL FOUR-STROKE-CYCLE TYPES

A few years later the external crosshead was abandoned and the trunk pis-

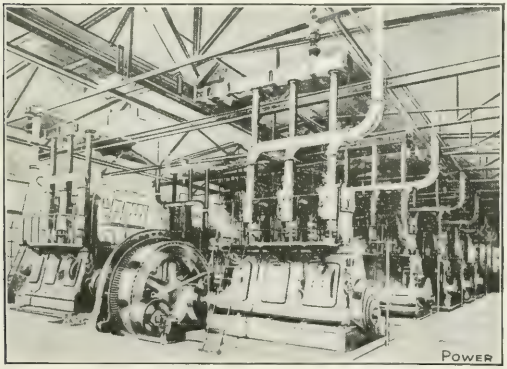


FIG. 4. PLANT OF PRAIRIE PEBBLE PHOSPHATE CO.

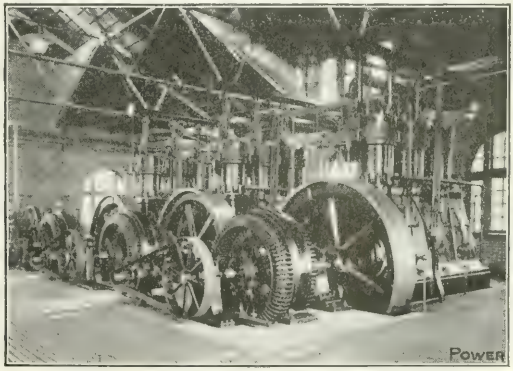


FIG. 5. PLANT OF UNITED GAS IMPROVEMENT CO.

ton adopted. Engines of this design having cylinders of 10 to 250 hp. each were constructed and by adopting the multicylinder type as high as 1000 hp. per engine was attained. These ran at comparatively low speed, from 160 to 200 r.p.m., and were of heavy construction. Gradually the sizes were increased, although the general design remained the same.

of this kind are now built up to 700 hp.

After the vertical engines had been in use for about 12 years, horizontal four-stroke-cycle engines were built. At first these were practically vertical engines laid on their sides without any independent structural innovations. Gradually, however, the details were altered in such a way as to render them more suitable for a horizontal position, and a type

gine into the United States and after it had proved successful here this departure

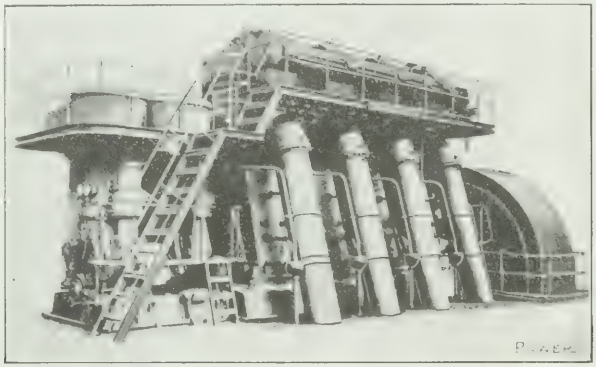


FIG. 6. LARGE TWO-STROKE CYCLE ENGINE

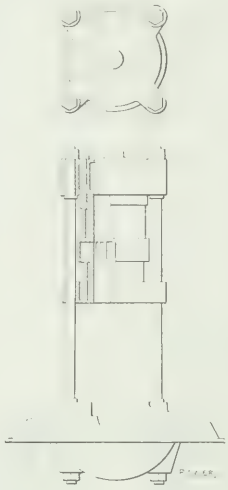


FIG. 7. LARGE CYLINDER UNIT ARRANGED TO ALLOW FOR EXPANSION

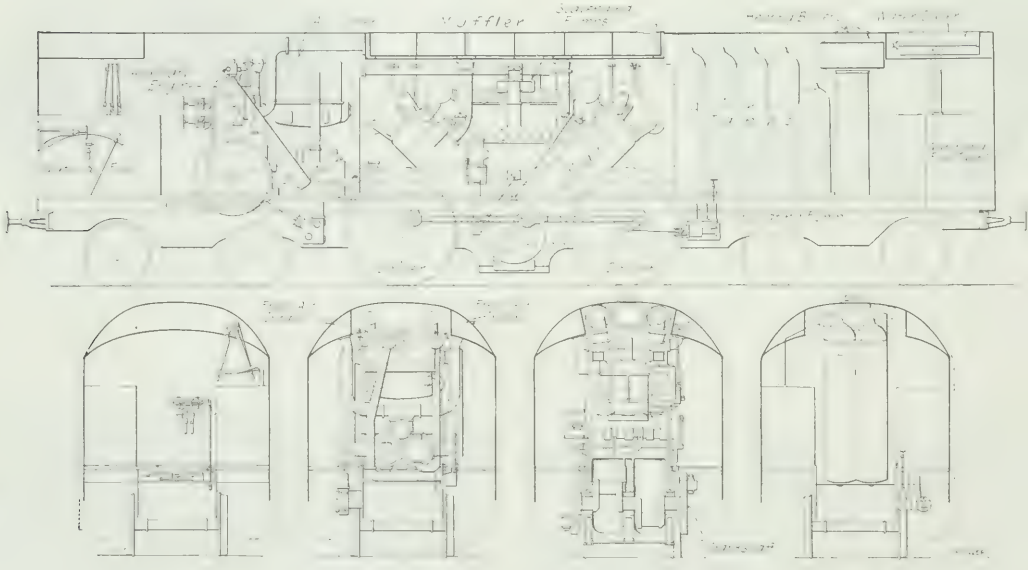


FIG. 8. GENERAL LAYOUT OF DIESEL LOCOMOTIVE

As the central stations took up the Diesel engines, the necessity arose for higher speeds. Accordingly, engines were built with speeds ranging from 300 to 600 r.p.m., the principal difference between these and the earlier type being that the cylinders were supported by light steel columns instead of heavy cast-iron frames. This reduced the weight considerably. Four-stroke-cycle engines was evolved resembling very closely the horizontal gas engine. Double-acting four-stroke-cycle horizontal engines with two or four cylinders arranged tandem are now built in sizes up to 2000 hp.

AMERICAN PRACTICE

The abandonment of the crosshead and the adoption of the trunk piston began with the introduction of the Diesel engine into the United States and after it was followed by the European builders. Other modifications adopted in American practice were a closed base frame, valves in a chamber at the side of the cylinder instead of in the head and an independently driven air pump. Some of these modifications have now been adopted in European practice and others are about to be.

Dr. Diesel stated the aggregate of

Diesel engines in the United States is at present about 300 units, having a combined horsepower of 150,000. He then showed views of a number of these plants. The largest is that of the Prairie Pebble Phosphate Co. at Mulberry, Fla. This is shown in Fig. 4 and comprises sixteen Diesel engines arranged in eight double units of 450 hp. each, and served by five air compressors.

Another important American Diesel engine plant is that of the United Gas Improvement Co. in Philadelphia. This is shown in Fig. 5 and has three 225-hp. engines.

Two-stroke-cycle Engines

It will be remembered that in the Diesel engine the scavenging is not done with a mixture of fuel and air, but with pure air; thus one source of fuel loss is avoided, making this type especially adaptable to the two-stroke cycle. Dr. Diesel admitted, however, that the four-stroke-cycle engine was still the more efficient, due to better combustion. On the other hand, the two-stroke-cycle engine, owing to its smaller cylinders, has come into favor for stationary plants of higher power and for marine work. Two types of the two-stroke-cycle engine have so far been in competition. That built by Sulzer Bros. has a separate scavenging pump and the other, built by the Maschinenfabrik, Augsburg, Nürnberg, has the scavenging pump, which has an annular piston, placed underneath each combustion cylinder. Both engines are single acting. A four-cylinder two-stroke-cycle Sulzer-Diesel engine of 2400 hp. is shown in Fig. 6.

Marine Engines

In reviewing the application of his engine to marine practice, Dr. Diesel stated that at the start attempts were made to make the four-stroke-cycle engine reversible. This resulted in a very complicated mechanism, and, although a few of these are still being built, this type has almost entirely given place to the reversible two-stroke-cycle engine, which for marine work also embodies other advantages, such as less weight, etc.

Very important experimental work is now being carried on for the purpose of developing high-power marine engines with cylinder units reaching 1000 to 2000 hp. In this connection Sulzer Bros. have just completed a single cylinder of 2000 hp. with single-acting piston based on the construction shown in Fig. 7, which permits free expansion of the cylinder under the action of high temperatures.

Dr. Diesel stated that there were at present 365 ships fitted with Diesel engines. One of these, around which popular interest centers, is the "Fram," in which Capt. Amundsen made his successful trip to the south polar regions.

Also two submarines for the United States Navy are being fitted out with Diesel engines.

Diesel Locomotive

One of the most interesting points covered by Dr. Diesel's lecture was the application of his engine to locomotives. This is an entirely new phase of the subject and, although experiments have been in progress for the past five years at the Winterthur works of Sulzer Bros., practically nothing has heretofore been made public regarding it.

The first locomotive, which is of 1200 hp., has just been completed and is at present undergoing tests. This is represented in Fig. 8. The application of the Diesel engine to locomotive practice presented a rather difficult problem, owing to the difficulties of maneuvering with this type of motor and to the limitations in space and weight.

Referring to Fig. 8, the motor is a two-stroke-cycle Diesel engine with four inclined cylinders set in pairs at an angle of 90 deg.; the cranks, however, are set at 180 deg. to afford a balancing effect. Between the working cylinders are placed two scavenging pumps driven by links from the connecting-rod. At one end of the car is placed an auxiliary engine which drives the horizontal air pumps. These serve to increase the power of the main engines when starting, maneuvering and going up hill, in such a way that auxiliary compressed air and oil fuel are supplied to the cylinders. For ordinary running the engines work like an ordinary Diesel motor.

Air-storage tanks are provided for supplementing the work of the auxiliary pumps. At the top of the car at one end is a device for cooling the circulating water, and for heating the train a small donkey boiler is installed. The total weight of the locomotive is about 85 tons and the outcome of the tests now being made upon it is awaited with keen anticipation.

To substantiate the claims made for his engine, Dr. Diesel produced a set of curves (Fig. 9), showing a comparison between an ordinary noncondensing plant, a condensing plant, a producer plant and the Diesel engine, all based on the heat consumption per unit of power per hour. This unit was a "pferdekraft," which is equivalent to 0.9863 hp. in English units.

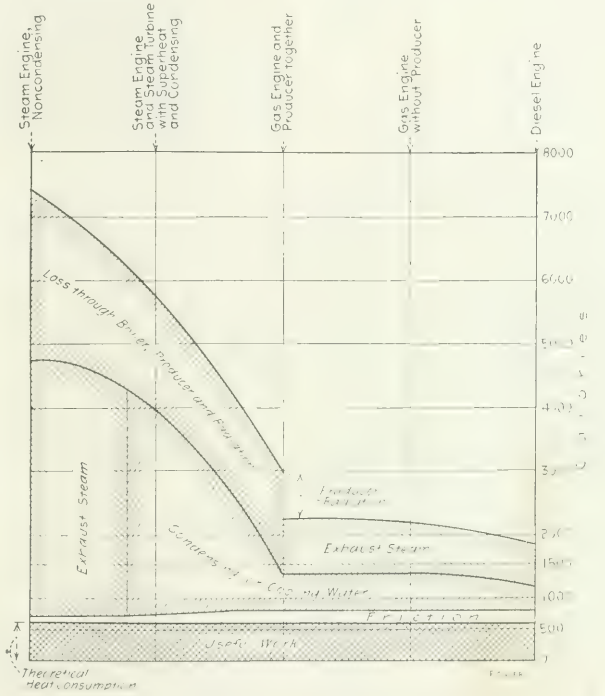


Fig. 9. Heat Distribution in Different Types of Plant

The American rights to the later Diesel patents (the early ones having expired) have been taken over by the Busch-Sulzer Bros. Diesel Engine Co., of St. Louis, who are now erecting a large plant capable of turning out many thousand horsepower in Diesel engines yearly. We are indebted to this firm for the illustrations herein shown.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Heating and Ventilation of New Bosch Factory

The Bosch Magneto Co., of New York, has erected at Springfield, Mass., a factory for the manufacture of Bosch products. The plant is located between North Main St. and the Boston & Maine R.R. and at present comprises the manufacturing building, the power house and the boiler house, besides a number of smaller temporary buildings. The buildings are arranged to form a large block,

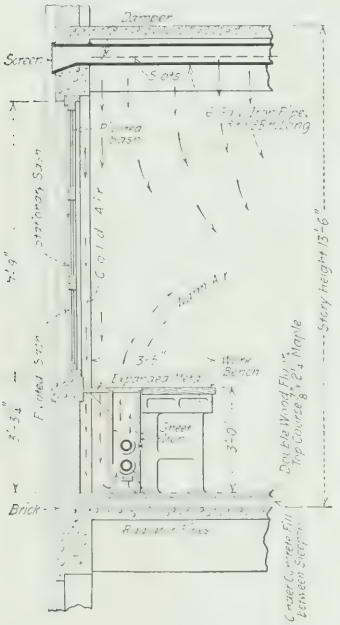


FIG. 2. TYPICAL WINDOW, RADIATOR AND WORK BENCH ARRANGEMENT

inclosing two light courts in which the power and heating plants will be located.

HEATING

Heating is effected by what may be termed an indirect system. It uses air as the convecting medium, but it differs from the ordinary system of indirect heating in that instead of one large heater through which the air is forced with great velocity, there are a great many ordinary radiators along the outside walls, around which the air travels rather slowly. The radiators are supplied with low-pressure steam, the condensation returning to the boilers by gravity. Two cast-iron sectional boilers, each of 30-hp. capacity, supply the steam. The boiler house is placed entirely underground.

The gases of combustion pass through economizers, Fig. 1, where a part of their

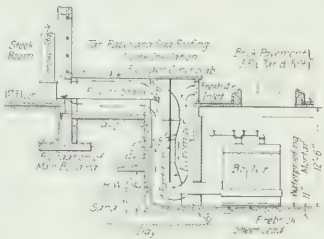


FIG. 1. SAVING HEAT OF FLUE GASES

heat is taken off and they are then led to the smoke-stacks erected within the main building. In this way a great part of the heat from the gases is utilized. An enclosure about 9 ft. high on each floor protects the workmen against the direct radiation of the smokestacks. The warm air coming from the economizer room is used to heat the stock room on the first floor, which is next to the boiler house and occupies about one-quarter of the floor. As the amount of heat furnished by the economizers is much greater than necessary for the stock room, part of the warm air will be piped to the upper stories.

The radiators are made up of cast-iron pipes with radiating fins to increase the heating surface. The arrangement of the radiators may be seen in Fig. 2, which shows a cross-section through the outside wall at a window. The radiator is separated from the outside wall by a partition of sheet metal which extends from the window sill to the lower part of the radiator. It is also separated from the interior of the room by a partition running from the window sill to the floor. The two partitions together with the outside wall form a casing with two separate spaces covered on top by expanded metal. When the radiator is heated the surrounding air will rise in the inner space and draw the cold air through the space next to the wall. The cold air comes through the outer space and rises in the inner space of the radiator casings. The warm air leaving the casing is drawn away by the suction caused by exhaust fans located in the main-stair tower.

This arrangement of the radiators has a number of advantages over the old method of setting them directly against the wall. The losses of heat through the walls and windows are reduced and the lower part of the wall is protected against direct radiation.

The work benches can be set directly against the radiator casings as the rising warm air protects the workmen from

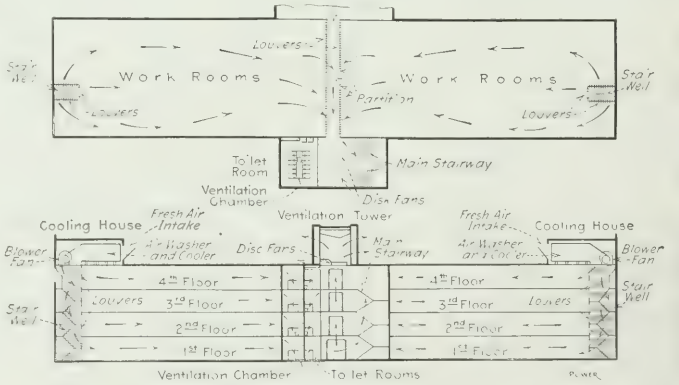


FIG. 3. GENERAL OUTLINE OF VENTILATING SYSTEM

draft and cold and the inner walls of the casings keep off the direct radiation.

VENTILATION

The buildings are ventilated by mechanical draft. See Fig. 3 for the general arrangement. The stairwells are used as ventilating flues, and the exhaust fans, Fig. 4, are placed near the top of the stairwell. There are two disk fans at the top

FIG. 4. EXHAUST FANS IN MAIN STAIR WELL

of the main stairway, each having a maximum capacity of 100,000 cu.ft. per minute. The discharging capacity of the two fans together can be varied from 50,000 to 200,000 cu.ft. a minute. A blower fan of 30,000 cu.ft. capacity is placed over each of the other two stairways, on the north and south ends of the building. The direction and intensity of the flow of air through the workrooms to the exhaust fans are regulated by louvers, see Fig. 5, which are placed in the partitions that divide the working rooms of the main building. These partitions divide each floor into two parts, forming a passage way between, running from the main stairs to the wash rooms. Louvers are also provided in the walls of the stairways on the north and south ends.

The ventilation of the forge room and the men's toilet room on the first floor and the hardening room on the second floor is separate from the general ventilation to keep the fumes and gases out of the general work rooms. Two blower fans draw the air from these rooms and carry it through a chimney flue on the roof into the open air.

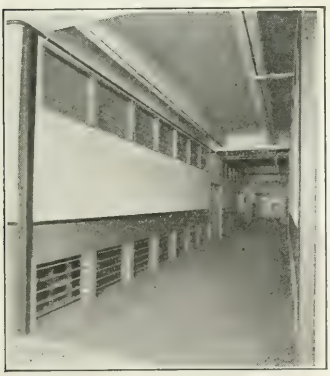


FIG. 5. VENTILATING LOUVERS IN CORRIDOR

The operation of the general ventilating system can be varied, depending on weather conditions. In winter the disk fans in the main stair tower are used only for producing a change of air twice every hour. Part of the fresh air enters through the walls and the joints of the windows; the rest is taken in through galvanized-iron pipes which run along the ceiling and through the outside walls into the open air. The pipes are of 6-in. diameter and vary in length from 8 to 25 ft. according to their distance from the main stairs. The cold air enters the rooms through a number of thin slots in the pipes, shown in Fig. 6, and in dropping mixes with the warm air that is constantly rising. The temperature in the rooms is therefore kept very uniform and the heat is used to the best advantage.

The air is drawn toward the center partitions and escapes through the bottom louvers into the stairwell, from where it is drawn out by the fans. The fans discharge the foul air into a chamber on top of the roof, where it passes into the open. This ventilating system has been in operation during the past winter, and, in combination with the heating system, has proved to be very satisfactory. Although the loss of heat from the ventilation is considerable, the consumption of fuel is well within the expected limits, a fact largely due to the insulating effect of the double-glassed windows, the radiator casings and the heat-saving arrangements of economizers, smoke-stacks and air-intake pipes.

As the weather becomes warmer and the windows can be opened, the change of air is gradually increased. If the two blower fans over the small stairwells are used as exhaust fans, together with the two disk fans in the main stairwell, it will be possible to change the air 12 times an hour; the draft near the windows will be quite perceptible if the opening of the windows is properly regulated. This can be easily done, as they are controlled by unit drives and cannot be opened by the workmen.

In hot weather, the exhaust fans in the main-stair tower will run during the early morning hours and will draw the cool night air through the building. Thus the interior of the building will be cool in the morning and the effect of the cooled concrete columns, beams and floors and the metallic contents of the buildings will help considerably in keeping down the temperature of the interior air.

FIG. 6. SLOTTED FRESH AIR PIPES

During very hot weather, a change of air would not be of advantage, the temperature of the outside air being so high that it would offer no relief to draw it into the building. When such conditions prevail, it is intended to close all windows, bring the fresh air in through the two stairwells at the north and south ends of the building, and cool this air before it enters the work rooms. For this purpose, two air-cooling machines are installed, one on top of each stairwell. The cooling machines, one of which is shown in Fig. 7, are of the water-spray type. The air is taken in through an opening in the penthouse, enters the cooling machine, is drawn through the water spray, passes a number of baffle plates, where it loses its

free moisture, continues through the fan into the stairwell and passes from there through the louvers into the work rooms. After it has circulated through a work room, it leaves through the upper louvers in the center partitions, and is drawn into the main stairwell and exhausted. The water for the air-cooling machine is taken from the well at the rate of about 60 gal. per min. for each machine and at a temperature of about 54 deg. F. With that quantity of water, it is guaranteed by the manufacturer of the cooling machines that air entering at 95 deg. F., and containing 9.3 grains of moisture per cubic foot, will be cooled to 78 deg. It is calculated that under these conditions, it will be possible to keep the temperature inside of the building about 9 deg. lower than the outside, changing the air four times an hour.

While the ventilating and heating apparatus have been tried out during the past winter, it has not been possible to operate the cooling machines. As this is practically the first attempt that has been made to cool large work rooms with a view to improving conditions for the workmen of a factory during hot weather, it is expected that a number of complications might arise that will make the problem more difficult than it appears, but it is thought that with the ventilating machinery as now installed, it will be possible to overcome these difficulties.

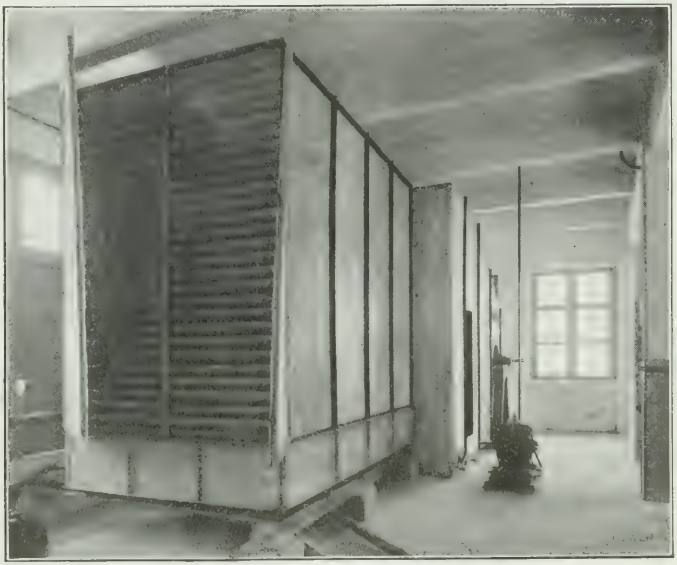


FIG. 7. AIR COOLING MACHINE

POWER PLANT

The machine tools are arranged for group drive. The mainshafts are about 60 ft. long, each being driven by an induction motor of 10-, 15- or 20-hp. capacity. Electrical energy is supplied at present by the United Electric Light Co., of Springfield. A private power plant, located in the power house, is in course of erection, consisting of a 280-hp. Diesel engine connected to a 200-kv.-a. Westinghouse generator, which will furnish current for both power and light. When this plant is completed, it is intended to use the outside supply as a reserve.

Arrangements have been made so that the load can be distributed between the two supplies at any ratio without running the two systems in parallel.

CORRESPONDENCE

Why Does the Pump Race?

I have occasionally had duplex pumps knock and race as described by Mr. Moulton in the Apr. 2 issue. The fundamental reason underlying this is that the pump does not carry its water to the end of the stroke; consequently there must be gas, steam or vacuum present in the water cylinder. As this condition will not present sufficient resistance to the steam, the pump will knock on the end of strokes and race.

Mr. Moulton says he shuts off the steam heat and opens the vacuum breaker.

This will lower the pressure on the water and it will immediately develop steam, particularly in the pump-valve chambers and in the suction pipe; this is why the pump gets steam instead of water and is the direct cause of the trouble. The obvious remedy is to keep the tank at a uniform pressure.

I do not see the necessity for the equalizing tank; a regulating float valve could have been used in the large tank.

W. A. COOIL.

Ladysmith, B. C.

In the light, power and hot-water heating plant where I am employed we have a battery of four boilers bleeding live steam into three exhaust condensers and live steam only into No. 4 condenser for heating.

The condensation from No. 1 condenser goes into an open feed-water heater while from Nos. 2 and 3 it goes into an open tank, and the suction pipe from the open heater and tank is connected together under the floor.

When live steam is shut off in Nos. 1, 2 and 3, or city water is turned into the heater, a partial vacuum is formed in the heater, drawing the water away from the open tank and closing the throttle on the pump till conditions become normal again. This pump never races.

The condensation from No. 4 goes into a closed tank and then to No. 2 pump. This pump is also controlled by a throttle operated by a float valve in the tank.

When too much steam is shut off at once a partial vacuum is formed in the tank, preventing the water from flowing to the pump, which causes it to race. By shutting off just a little steam at a time no vacuum is formed.

We do not use an equalizer such as Mr. Moulton shows in his diagram. If he would disconnect the equalizing pipe from both return and equalizing tank and leave the equalizing tank open to the atmosphere, it would prevent the pump from racing provided there is no pressure in the return tank.

R. F. CALDERWOOD.

Ida Grove, Iowa.

Germany Honors Fair Commission

On May 7 the Panama-Pacific Exposition Commissioners were received in Berlin, Germany, by distinguished government officials and invited to explain the purpose of the fair.

Chairman John Hays Hammond said the commissioners' visit to Germany was merely to familiarize that country with the scope of the enterprise and they did not ask any definite promise of participation.

The officials evinced a lively interest and marveled at the work which has already been accomplished since the San Francisco fire six years ago. It is believed that the plans for the coming exposition will be favorably considered in Germany and that its people will actively participate in the exhibits shown by other European governments.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Diesel Engine in the United States

Why the Diesel engine, with its high efficiency, has not been used more extensively in this country is a question often raised. While there are more of these installations than has been generally supposed, as reference to the article elsewhere in this issue will show, still the number of Diesel engine plants in the United States is comparatively small.

Many have tried to account for this by asserting that the workmanship here is inferior to that in Europe and that the operators are less skilled. Dr. Diesel, however, during his recent visit, refuted this statement. He claimed that the Diesel engines built in this country, after having passed the necessary manufacturing apprenticeship stage, are quite as good as those of European make; furthermore, they are handled as intelligently. In his opinion, the question is purely economic.

In Europe the leading idea seems to be operating cost while here it is first cost. This may be explained partly by the facts that our rates of interest are higher, coal much cheaper, and steam engines cheaper than in Europe. The Diesel engines, owing to their necessarily heavier proportions and special features of design, are expensive.

Moreover, in American practice obsolescence is a factor to be reckoned. Improvements in prime movers have been so rapid that it is common to see machines, although in perfect operating condition and only eight or ten years old, being displaced by those of the latest design. Under such conditions it would be unwise to invest heavily in apparatus which would be superseded in a few years. Therefore, American engineers seem to have been content to watch developments until the Diesel engine has reached a stage of perfection such that would warrant the increased investment.

Within the past two or three years, however, conservation and "efficiency" have been impressed upon the American public to such an extent that it is reasonable to assume that more attention will henceforth be given to economy in production. This will undoubtedly open the field for the Diesel motor.

The Size of Pipe

When installing a heating system, one of the largest items of the initial investment is the cost of the piping. Any reduction in diameter means a considerable saving, so that the arrangement which will deliver a certain amount of heat through the smallest pipe has an advantage which would naturally tend toward its selection.

It is frequently claimed, and quite generally believed, that the supply main of a vacuum system need not be more than half, or at most two-thirds, the size of the main required for a system having an initial pressure above atmosphere. Providing the latter has been properly designed and provision is made for removing air, it is difficult to see why this should be true.

When the pressure of steam close to the zero mark on the gage is reduced, the volume increases rapidly and will require a more rapid flow for the same delivery. The friction varies nearly as the square of the velocity, the latter being due to the difference in pressure between the terminal and initial points less the friction head. As a vacuum system is generally intended to reduce back pressure and the return is cooled to produce a difference in pressure below the initial point, why should there be any reduction in the size of main with the corresponding increase in volumes and reduction in temperature?

Suppose an initial pressure of five pounds gage were used in one case and atmosphere in another, the volumes would be 20.44 and 26.79 cubic feet per pound respectively, with a difference of only six heat units in favor of the higher pressure. This would indicate that for the same loss in friction and output in heat units the lower pressure will require a main nearly one-third larger rather than one two-thirds the size.

Of course, air in the system is a factor which must be considered, and not

infrequently it operates to the disadvantage of an improperly arranged system.

A case in point is a certain plant which had a ten-inch main. Due to the arrangement of the piping, there was excessive back pressure, so that the radiation became air-bound and did not receive sufficient steam to heat the building properly. A vacuum system might have cleared the radiation of air, restored the circulation and perhaps showed that a six-inch main would be all that was required for the work. This simply means, however, that a smaller pipe under pressure would have handled all the heat units actually transmitted and is no argument for smaller mains under conditions of lower pressure and greater volume.

Should an Engineer Purchase Instruments?

The letter on page 782 of this issue under the above heading has an excellent suggestion.

True, this question will long remain open, but many who argue negatively lack foresight rather than ambition, and this partially explains their attitude. There are thousands of engineers who either continuously or intermittently have eight or more leisure hours every day, and while many spend them in endeavoring to increase their earnings, some become discouraged if a suitable channel of activity does not suggest itself. As suggested in the letter, the ambitious engineer could make tests in neighboring plants, profitably using his idle hours and gaining prestige and reputation.

A complete indicator outfit may be purchased for from forty to sixty dollars, a three-pipette Orsat for about thirty-five dollars, and a satisfactory flue-gas sampling outfit can be easily made by almost any engineer. The cost of handbooks is not prohibitive, and a few will answer one's needs. It does not require much knowledge of chemistry or extensive paraphernalia to make practically accurate tests of boiler waters, or to effect their cure. Much of the apparatus can be made at home or in the shop.

An engineer could equip himself for test work for about one hundred dollars, and there are concerns which will willingly pay well for it, and add a bonus if the results justify it.

Allowable Boiler Pressure

At a recent meeting of boiler inspectors the discussion of pressures allowable for steam boilers brought out some interesting facts.

Frequently a boiler built to withstand a working pressure of 125 pounds per square inch is operated at 100 pounds pressure. This may be because an underloaded engine, with the higher steam pressure, will expand the steam in the cylinder below atmospheric pressure and produce what is known as a negative loop on the indicator diagram. Running the engine with a reduced steam pressure will eliminate this undesirable condition. Here is where the engineer and the boiler inspector disagree. The inspector is quite apt to conclude that if only 100 pounds pressure is required to operate the plant, the boiler should be limited to that pressure. This is certainly on the side of safety, but it is hardly a scientific method of dealing with the question.

Engineers object to any reduction in the allowable pressure because they realize that, some time, it will be necessary to maintain the highest pressure the boiler can safely carry. Experience has taught them that it is easier to regulate the safety valve to blow at 100 instead of 125 pounds pressure than it is to induce the inspector to increase the allowable pressure from 100 to 125 pounds. Therefore, while favoring reducing the actual boiler pressure where economy will be improved, they do object to the inspector changing the allowable pressure carried.

One inspector stated that he allowed all the pressure a boiler would, according to his judgment and calculation, carry, and set the safety valve so close to the working pressure that it would frequently operate, thus preventing the valve from becoming inoperative through nonuse. This is good practice; it would be inviting disaster to reduce the boiler pressure to 100 pounds per square inch and have the safety valve set to operate at 125 pounds. On the other hand, there is no good reason why a boiler should not be allowed to carry 125 pounds per square inch, although it has been working at a less pressure, providing it can safely do so.

In some cities it is almost impossible to get permission to increase the working pressure after running with a lower one. There is no apparent reason for this attitude on the part of an inspector, unless it is a desire to err on the side of safety, which, however, is likely to put the plant owners to unnecessary inconvenience and perhaps to the expense of installing a new boiler.

Talking and Doing

Discussing ways to better the conditions of power-plant employees is some good if it sets them thinking. No real and permanent benefit results, however, until the thinking develops into action. A vaccination does not count until it "takes." POWER is long on suggestions as to what should be done, and how, but short on letters telling what has been done.

We have tried to inoculate our readers with ambition to advance themselves and improve their surroundings. Now it would be a vindication of our preaching and an inspiration to those who have not applied it yet, to hear from those who have.

Perhaps our sermons had nothing to do with your success. Never mind, we are not looking for glory, but if the principles we are advocating are right, support us. Write us how you conquered difficulties, what your greatest help was, and anything else that will encourage the fellow who is still at the bottom of the ladder and not very confident of his climbing ability. Do not let modesty keep you from giving others the benefit of your experience.

We maintain that the power-plant employee, if he really expects to ultimately reach one of those better places at the top, must improve his spare time by keeping alive to the advance in his field and, being well grounded in such knowledge, must have the courage to let it be known.

"Example is better than precept." If you are one of the successes whose experience confirms our statements, a few words from you will do more good than all our moralizing.

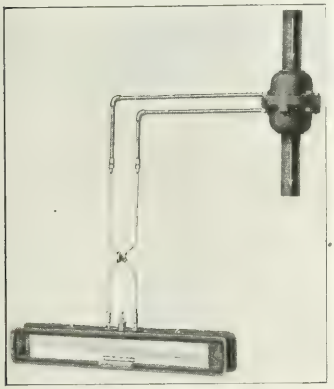
Engineering for Apr. 25 reports a turbine test in which a kilowatt-hour was developed on 11.1 pounds of steam. This would be the record if true, but the original data gives a consumption in metric units equivalent to over 12 pounds.

Gas Economy Indicator

The accompanying illustration shows a gas economy indicator, which is manufactured by the Meriam Co., 5606 Euclid Ave., Cleveland, Ohio.

An orifice casting is placed in the gas or air-supply line and is connected with ⅛-in. pipe to the indicator, which is practically a U-tube and operates on the same lines as a draft gage, the difference in pressure being a measurement of inflow.

The pressure on both sides of a copper disk in the orifice casting is transmitted to the opposite ends of a glass tube containing a red liquid. The flow of gas through the orifice is indicated on a graduated scale by the movement of the red liquid, and is shown in cubic feet per hour. This device enables a gas-engine operator to detect any irregularities in the gas consumption, and to regulate the engine for the most economical and efficient operation.



Gas Economy Indicator

Any changes or adjustments in the ignition or mixture will instantly be shown on the indicator by the movement of the liquid, and will indicate whether these changes have improved the economy. After once determining the adjustment at which the engine operates most economically on a given load, should the indicator at a subsequent time show a greater consumption of gas with the same load, this would indicate a waste of gas caused by either foul or defective spark plugs, leaking pistons or valves, or improper adjustment.

Two types of instruments are manufactured, one containing a single tube for use with engines operating on natural or artificial gas, and the other containing two tubes for use with engines operating on producer gas, one of the tubes being for gas and the other for air.

In addition to using the instrument on gas engines, it may be adapted for use with gas producers, and in fact any place where it is desirous of knowing the exact flow of gas or air, so that it may be kept at a fixed rate, regardless of the pressure.

McEwen Centrifugal Pump

The most notable feature of this pump is its radical departure from the ordinary type of turbine runner, and the substitution of a runner of either helical or propeller type, depending upon the head and the speed. The general construction is otherwise modified to better meet the demands of high speed.

Water enters the suction inlet and flows in a spiral path through a volute suction passage where it is parted to flow equally into each side of and naturally balance the impeller as shown in Fig. 1. The water is delivered from the periphery of the impeller into a volute

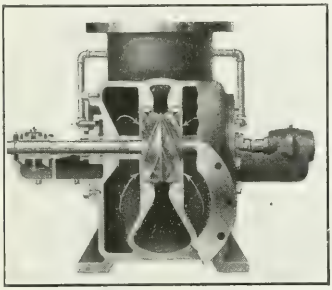


Fig. 1. Balanced Impeller

outlet chamber through the discharge outlet, shown in Fig. 2. To compensate for possible inequalities and abnormal conditions, thrust collars are provided on the inner ends of the bearings. The impeller is allowed to find its own center during a running test; the collars are then set and thereafter hold the impeller in the position of highest efficiency.

The outer edges of the vanes are helices, while the main body of the impeller consists of two cone frustums with opposed bases. The water is thrown from the impeller at a velocity required by the head, and in streams which have parallel flow through the throat and annular nozzle into the volute, and the velocity is there converted into pressure.

Where desirable to maintain steam-

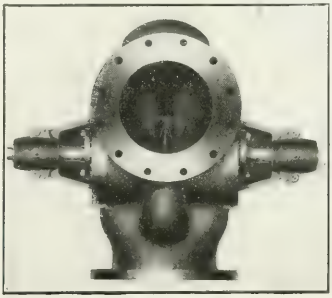


Fig. 2. Discharge Outlet

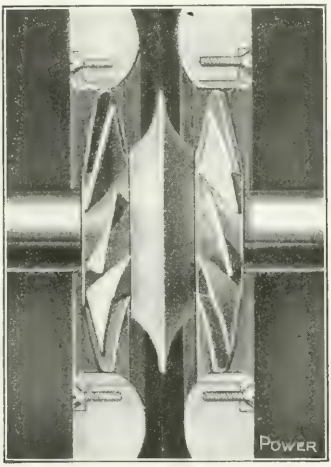


Fig. 3. Propeller Type Impeller

turbine speeds at the low heads of 5 to 20 ft., the helical blades of the standard impeller are replaced by blades of the propeller type which are really helical blades cut short and given an increased pitch to suit the head required. They are shown in Figs. 3 and 4. The cone body of the helical impeller serves as a deflector for the propeller. The two types of impeller are interchangeable in the same casing. An end view of the discharge chamber is shown in Fig. 5.

The interior of this pump is accessible

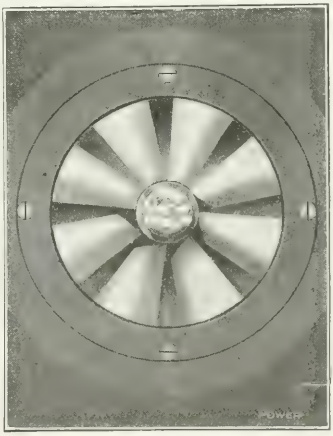


Fig. 4. End View of Impeller

without breaking the pipe joints, and the removal of the impeller involves only the breaking of a small ring joint and removing one bearing head.

The shell is cast in one piece, ma-

chined and provided with renewable bronze wearing rings where the impeller runs close. The impeller is made of bronze, and is built up of two halves. The outer edges of the blades are machined to a running clearance with the

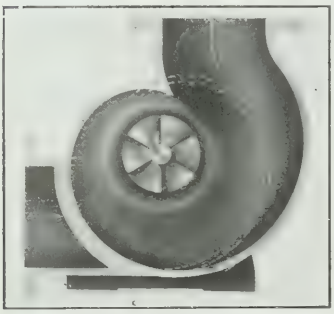
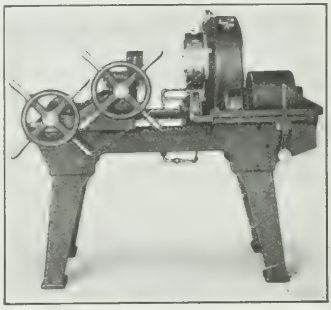


FIG. 5. DISCHARGE CHAMBER

wearing rings in the shell. The shaft is of nickel-steel and is entirely protected from the action of water by bronze protecting sleeves. The possibility of wear, due to the binding of the packing at

self-locking and self-releasing. The machine has two changes of speed operated by a gear shift; no countershaft is required, and tight and loose pulleys are furnished on the machine itself with a belt shipper.



PIPE THREADING MACHINE

The cutoff attachment is where it can be seen at a glance, even when the largest-size pipe the machine will take is being handled. Any size of nipple can be cut and threaded.

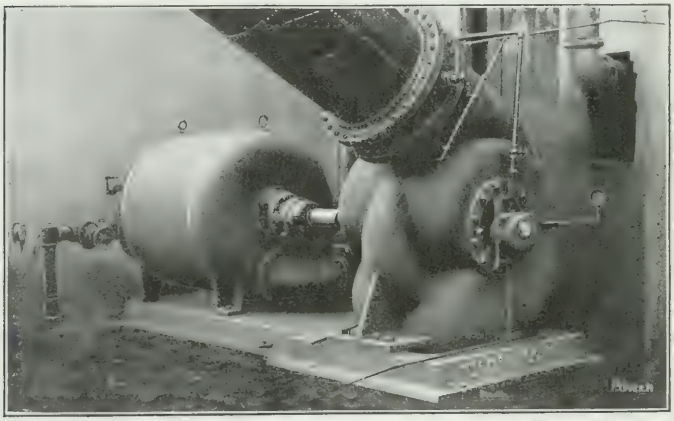


FIG. 6. SHOWING COMPACTNESS OF THE UNIT

the stuffing-gland is made unobjectionable as the wear comes on renewable sleeves. The compactness of the pump is shown in Fig. 6.

This pump is made by the McEwen Bros., Wellsville, N. Y.

Lathe-Bed Pipe Threading Machine

The requirement of the average user of pipe-threading machinery is a machine that will cut off and thread pipes and thread nipples without the use of a nipple chuck. The Loew-Victor lathe-bed machine has been designed to do this work.

It has the revolving die head which is

This machine is built for belt and motor drive by the Loew Manufacturing Co., Madison Ave. and Nickel Plate R.R., Cleveland, Ohio.

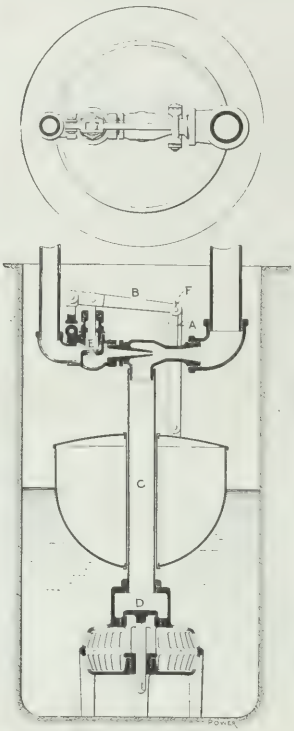
Automatic Pump Drainer

The Penberthy automatic ejector sump drainer, manufactured by the Penberthy Injector Co., Detroit, Mich., is operated by a jet of water controlled by a float and a quick opening and closing valve.

The float arm has a slot at *A* in which a pin in the valve-stem lever *B* slides. The float is compact, being made flat on top, and built around the suction pipe *C*, which is provided with a foot valve *D* inside the strainer. The valve is either

wide open or completely closed, utilizing the actuating water to the best advantage. When the float has risen until the p bottoms in the slot the valve *E* is the lifted from its seat by the float and th water pressure in the inlet pipe forces fully open, shock being avoided by th cushion formed above the valve disk.

The valve remains open until the wat in the sump lowers the float and th



AUTOMATIC SUMP DRAINER

top of the slotted arm engages with th pin *F*. Any further drop of the flo forces the valve downward and the su tion through the valve draws the valv to its seat without shock, due to th partial vacuum in the chamber above th valve disk.

New Rice & Sargent Engin Governor and Stop Motion

These have been recently brought ou by the Providence Engineering Work Providence, R. I. The governor has tw segmental weights with a spiral sprin in tension connecting directly betwee them. The weights are mounted wi roller bearings on bell cranks, which la ter are connected to the usual slidin sleeve-and-collar arrangement. The ce ter of gravity of each weight is in lin with its bearings, and an arm on th

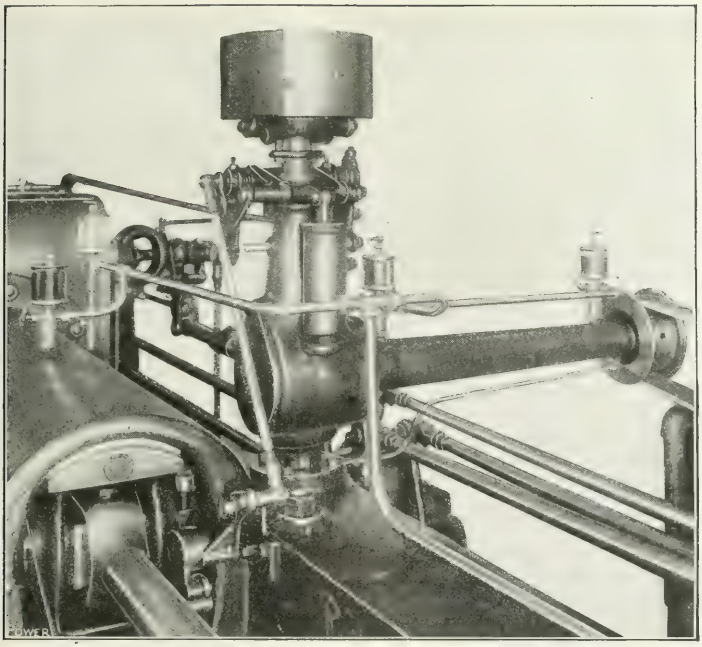


FIG. 1. GENERAL ARRANGEMENT OF GOVERNOR AND LATCH COUPLING

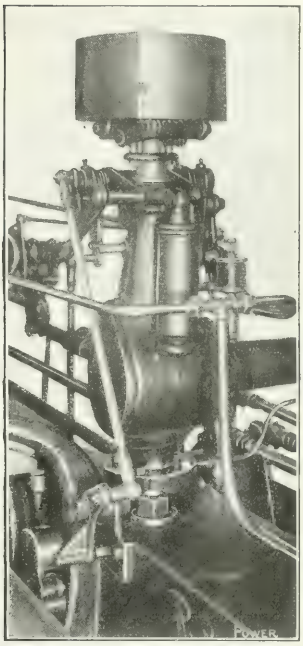


FIG. 2. LATCH RELEASED

weight is guided by the other weight, so that the two weights are kept in the same plane. The spring is easily adjustable for stability and change of speed.

The stop motion is operated by an inertia weight carried by the engine crosshead. Normally, this weight is held back against a stop by an adjustable spring, and remains quiet in relation to the crosshead; but when the engine exceeds a certain speed, the inertia of the weight overcomes the spring at the end

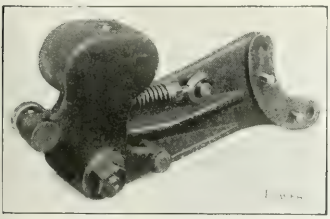


FIG. 3. WEIGHT AND BRACKET

of the engine stroke, so that the weight moves forward from the crosshead about 3/8 in. and strikes a hammer blow against a lever pivoted to the bedplate, thereby releasing a latch and allowing the valve-gear to be moved up by a spring to the zero cutoff position, corresponding to the highest travel of the governor.

Fig. 1 shows the general arrangement of the governor and also the position of the latch coupled up, ready for running.

Fig. 2 shows the latch released after the stop motion has operated and the levers connecting to the valve-gear moved up to the zero cutoff position. Fig. 3 shows the weight and its bracket, which is bolted to the crosshead. Fig. 4 also shows the latch released, and some of

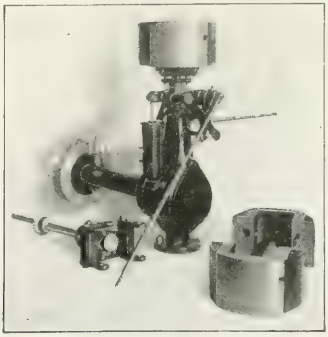


FIG. 4. PARTS OF GOVERNOR

the main parts in detail. These levers may be drawn back and latched in again at any time when the engine is below the speed limit.

This stop motion does not require any attention when shutting down the engine or starting up, and the full movement of the governor weights is available for useful work. The stop may be tested at any time when the load is off the engine by pulling down on the levers to speed the engine up to the limit, which is usually 5 to 10 per cent. above the normal speed of the engine.

Where it is desired to use push-buttons for stopping the engine from distant points, a separate electrical arrangement is used whereby a weight is released to fall and strike a blow on the latch mechanism to release it. This stop motion is also used in connection with the throttle valve to release a latch or toggle and allow the valve to promptly close. In this case the stop weight is on the other end of the crosshead and operates at the head end of the stroke.

Calculating Horsepower by the Slide Rule

The next edition of George W. Richardson's instruction book upon the slide rule will contain the following directions for calculating engine sizes, speeds, horsepower, etc.:

EXAMPLE—Find the cylinder diameter of an engine to develop 154 hp. with a piston speed of 600 ft. per minute, and a mean effective pressure of 42 lb. per square inch.

First—Set 154 hp. on the right half of the "A" scale adjacent to 6 (600 ft. per minute) on the left half of the "B" scale, Fig. 1, with the hair line of the runner set to 33 (33,000 ft.-lb.) on the left half of the "B" scale as shown.

Second—Move the slide "B" to the left until 42 comes under the runner (Fig. 2) and adjacent to the special graduation mark "X" on the left end of

the "C" scale, read 16 in. on the "D" scale as the required cylinder diameter for such an engine.

Rule 1—To find the horsepower, set the special graduation mark "X" on the "C" scale to the cylinder diameter (16) on the "D" scale, Fig. 2, and place the remaining the same, would require a corresponding increase or decrease of the mean effective pressure or cylinder diameter.

The calculation is simplified by putting a graduation mark at "X." In the example given

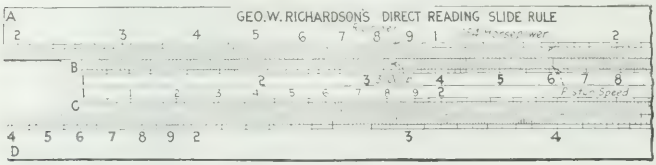


Fig. 1

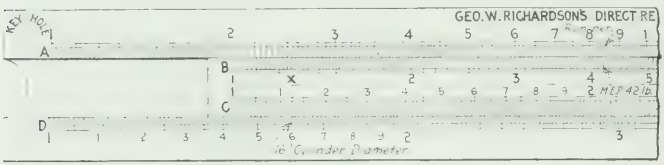


Fig. 2

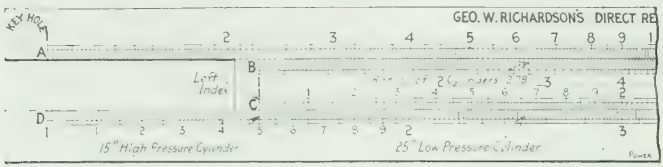


Fig. 3

OPERATIONS IN CALCULATING HORSEPOWER

runner to 42 (m.e.p.) on the "B" scale. Move the slide to the right (Fig. 1) until 33 on the "B" scale comes under the runner. Then read 154 hp. on the "A" scale over 6 (600 ft. piston speed) on the "B" scale.

Rule 2—To find the piston speed in feet per minute, proceed the same as in rule 1, except that the answer is read under 154 hp. on the "A" scale; read 600 ft. per minute on the "B" scale (Fig. 1).

Rule 3—To find the mean effective pressure of the same engine, set 154 hp. on the "A" scale, Fig. 1, against 6 (600 ft. per minute) on the "B" scale, and place the hair line of the runner to 33 (33,000 ft.-lb.) on the "B" scale, and leaving the runner at this point, move the slide until the special graduation mark "X" on the "C" scale is adjacent to 16 in. on the "D" scale, Fig. 2—and under the hair line of the runner on the "B" scale, read the answer 42 lb., mean effective pressure.

It will be noted with the setting as last explained, that if the slide "B" be moved back and forth, the mean effective pressure is increased or decreased, likewise the cylinder diameters are increased or decreased in the same proportion. The same ratio will be noted with a variation in piston speed; any increase or decrease in piston speed, the horsepower

$$Hp. = \frac{Pressure \times area \times piston\ speed}{33{,}000}$$

$$154 = \frac{42 \times area \times 600}{33{,}000}$$

and

$$Area = \frac{154 \times 33{,}000}{42 \times 600}$$

The operation as outlined consists in dividing 154 by 42, then by 600 and multiplying by 33,000. With this setting the index of slide "B" would be opposite the required area on the "A" scale. This area is

$$A = D^2 0.7854$$

then

$$D^2 = \frac{Area}{0.7854} = 1.273 \times area$$

The mark "X" is therefore put at 1.27 on the "B" scale and indicates by its position the square of the required diameter on the "A" scale and the diameter itself on the "D" scale. It is presumed that this special mark will be carried up on the "Richardson Rules" in the future

RATIO OF COMPOUND CYLINDERS

EXAMPLE—Required to find the ratio of two cylinders 15x25 in. in diameter

First—Set the left index on the "C" scale to 15 in. on the "D" scale. Next place the hair line of the runner to 2 on the "D" scale, and under the same line read 2.78 on the "B" scale (Fig. 3), which is the ratio of the two cylinders.

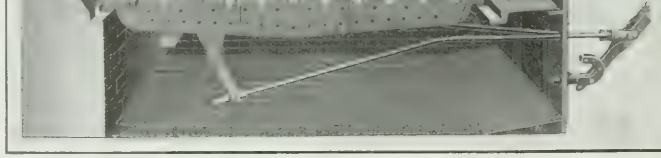
Suppose it is desired to have a triple expansion engine with the high, intermediate and low-pressure cylinders having a ratio of 2.78.

First—Perform the preceding operation, which gives the high- and intermediate-pressure cylinders. Then move the left index of the "B" scale to the hair line of the runner and move the latter to 2.78 (the given ratio) on the "B" scale. The diameter of the low pressure cylinder will be found under the hair line of the runner on the "D" scale, which is 41.5.

The cylinder sizes of a quadruple-expansion engine can be ascertained by extending the last operation in a similar manner.

Kelly Rocking and Dumping Grate

An improvement to the Kelly rocking and dumping grate, shown herewith, consists of a large rear dump grate which is operated independently of the main grate surface, and is for dumping the large clinker formation at a point which ordinarily receives the least attention.



IMPROVED ROCKING AND DUMPING GRATE

The fuel bed is broken up by the movement of the grate, and the rocking motion tends to shift the fuel toward the rear of the furnace. This grate is self-contained and its installation does not require any alterations in the ordinary furnace. It is the product of the Kelly Foundry & Machine Co., Goshen, Ind.

Readers with Something to Say

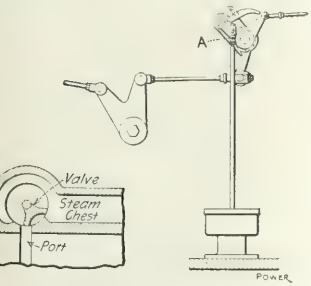
A letter good enough to print will be paid for. Ideas, not mere words, wanted

Corliss Engine Troubles

A 16x36-in. single-cylinder, double-centric, noncondensing Corliss engine fitted with double-seated steam valves rking over a single port passing steam der the two faces of the valve and er the two edges of the single port, shown in the illustration.

In looking over some back numbers POWER I read about setting the valves double-eccentric Corliss engines with gative steam lap and the main ec-ntric set back to get proper lead, thus lting a late cutoff adjustment up to ven-eighths stroke.

Wishing to be uptodate, I tried to get s adjustment on my Corliss, but after king the eccentric changes and short-ing the steam-valve rods, I found that was impossible to shorten them for gative lap or even line-and-line with-



DOUBLE SEATED VALVE AND CORLISS VALVE GEAR

t the valve-stem crank rising high ough to cause the dashpot rod to strike e valve crank as shown at *A*. I had put my valves back to about one-half toff.

This engine has run away three times thin a year, the first accident being e to the ball-bearing cone coming un-rewed in the governor, forcing the gov-nor rods to a position for a later cut-f until the governor weight had reached e limit of travel, and when the load opped the engine speeded up. As I as handy to the throttle, the local junk aler suffered a great loss in the profits rived from old junk. The other two naways were caused by the main shaft llar which carried the governor belt ming loose on the shaft, but still hav-g enough friction to rotate the gov-nor.

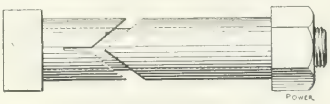
We did not shut down in either case, t pulled the load by blocking the gov-ernor and throttling the engine, which requires some maneuvering to run a generator smoothly.

E. C. SUTTON.

Estherville, Iowa.

Emergency Expansion Bolt

It sometimes happens that an engineer will require an expansion bolt, but on account of isolation or other unfortunate conditions, he cannot obtain it. Under such conditions, an expansion bolt may



EXPANSION BOLT

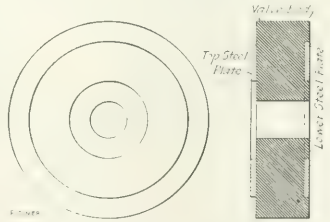
be made of two pieces of pipe cut as shown in the illustration. The pipes are then slipped over an ordinary bolt. Little time or expense is required to make it and it will serve for ordinary conditions.

J. DALY.

Brooklyn, N. Y.

Soft Valves and Hot Water

Some time after making an addition to our plant it became necessary to run the boiler-feed pump under widely varying pressures and feed-water temperatures. During the day the pressure and water temperature were considerably lower than at night.



REINFORCED PUMP VALVE DISK

Previous to the change in pumping conditions, soft flexible valves were used in the pumps with good results. Under the new conditions these valves would cut through between the ribs of the valve seats. As a relief for the trouble, metal and hard composition valves were tried, but with little success on account of the water containing much gritty matter; this required frequent regrinding of the valves and seats.

Then the following valve arrangement was tried with satisfactory results, and also admitted of using the soft valves: An annular space slightly less than the outside diameters of the rim and hub of the valve seat was cut out of both sides of the valves, as shown in the illustration. Two $\frac{1}{16}$-in. steel plates were used to reinforce the valve, one fitting on each side, as shown; countersunk rivets secured the plates. As these plates took all the pressure, the life of the valves was considerably lengthened; they also seat well, thus enabling the pumps to run at a very slow speed without slippage or noise.

D. H. HULL.

Asylum, Miss.

Influence of Speed on Cylinder Condensation

I do not find any definite or satisfactory information with regard to the influence of speed on cylinder condensation. Which has the greater effect, piston speed or rotary speed?

Which engine, for instance, will show the larger percentage of initial condensation, a 24x48-in. running at 80 r.p.m. or a 24x24-in. running at 160 r.p.m.? I should like to have the opinions of your correspondents backed up by reasons and test results.

B. T. ABBOTT.

Chelsea, Mass.

Failure of Boiler Tubes

One of the most serious troubles with water-tube boilers is the failure of the tubes. Is this due to tubes of inferior quality or to other causes? I have always noticed that in boilers of this type, whether horizontal or vertical, the tubes fail in a line with the baffle arch. After increasing the distance between the tubes and the arch I have lessened this trouble, but when this distance is increased from 15 or 18 in. to 28 in., is there not a loss in efficiency?

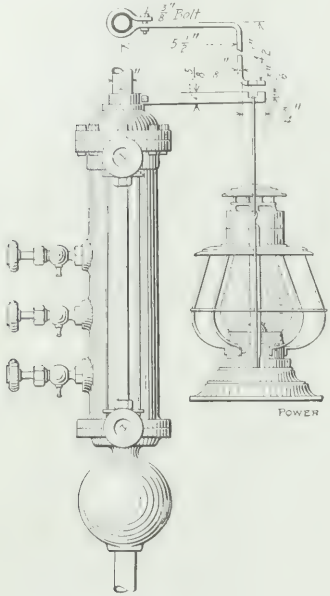
The bagging of tubes is oftentimes due to an accumulation of scale, oil or dirt at the ruptured part, but where an arch is built closely to the tubes it seems that bagging sometimes occurs when they are perfectly clean or when the amount of scale is so small that it alone is not the direct cause of rupture. Besides, the tubes sometimes break or leak badly at the tube sheet or header. What causes this?

W. J. MAXWELL.

Indianapolis, Ind.

Lantern Hanger

To make it convenient for the watchman to see from a distance the water level in the boilers, I made a lantern hanger, shown in the illustration, of mild steel. The loop around the pipe was bent on a separate piece of 1½-in.



WATER COLUMN LANTERN HANGER

pipe. The rest was bent as shown. When it was to be placed on the pipe of the water-column it was sprung open at the end of the loop and slipped over the pipe; then the ⅜-in. bolt was fitted and tightened.

FREDERICK L. JOHNSON.

Paterson, N. J.

Repairing a Blown Out Gasket

A portion of the gasket blew out in the inner head of one of our air-compressor cylinders, and we had to stop the leak without renewing the gasket, which would take from 24 to 30 hours and cause a shutdown of the whole plant.

After closing down for the day I made a paste of some iron cement and tamped it in the joint where the gasket blew out. A portion of the iron cement was then put on a block of wood which had previously been cut out to conform to the outline of the cylinder; the block was then securely bound to the cylinder by means of band iron drawn together with screws. The compressor was ready to operate the next morning and the leak had been effectually sealed; after running for several days, the block was removed.

The compressor has been running continuously for several weeks at 100 lb. pressure and the joint is still tight.

E. B. ANDERSON.

Rochester, N. Y.

Numerous Repairs

I had a plant to overhaul where everything had been left undrained the winter before, and it is needless to say that everything which could burst did so, especially the pumps. A duplex boiler-feed pump having burst in the suction nozzle, I repaired it by drilling a $\frac{5}{16}$-in. hole all the way through the broken piece and the wall that was intact. Then I cleaned the edges with muriatic acid and water and applied iron cement, pulling the edges together with $\frac{5}{16}$-in. bolts passing through the nozzle. This pump has had eight months' service without a leak.

Another pump had a snap piston ring broken. I needed one of 4 in. diameter to replace it, but could only find old rings that were 5 in. in diameter, one of which I made to fit by drawing it down to the required size. All that was necessary was to cut off the excess ends and file down one side until it fit the groove in the piston.

At another place I had to retube a horizontal return-tubular boiler. After knocking the old tubes out I found the shell and the heads in fair condition, except at one place at the top of the rear tube sheet the fusible plug had leaked, causing corrosion, and almost eating away a place about 1½ in. in diameter. As I was unable to get a boiler maker, I had to make this repair myself. I obtained a ¼-in. patch large enough to cover the defective area and riveted it on inside of the tube sheet, using red-lead putty between the patch and the sheet. I used six ⅜-in. rivets, which made a fair job, and they will last as long as the boiler, about two or three years, because of bad water and lack of proper attention. I reduced the pressure on this boiler from 100 lb. to 80 lb. gage.

This same plant had a deep-well steam pump that had frozen and broken the steam piston. I repaired this for temporary use until a new one could be obtained by countersinking holes in the top head and threading holes in the bottom head and using three ¼-in. bolts with countersunk heads to hold the heads together. Iron cement was used between the broken ends. This repair has been running nearly three years without using the new piston.

I have tried rivets instead of bolts to make a repair like this, but find that I cannot pull the heads together evenly with the rivets.

D. W. SCARBOROUGH.

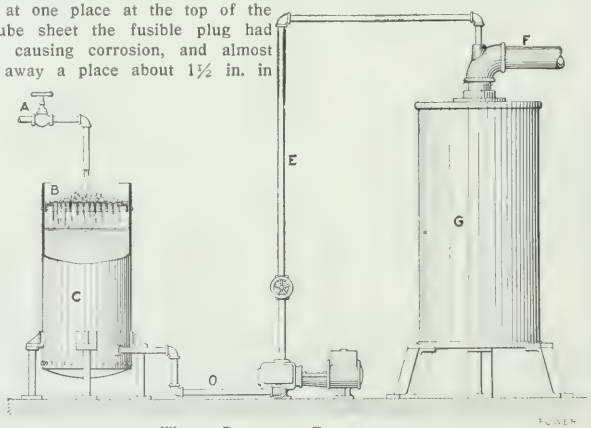
Richmond, Tex.

Treating Feed Water

In our plant we are treating the feed water with barium hydrate. River water is used in the boilers, and we take it directly from the condenser hotwell and pump it into the heater.

In treating the water we first dissolve the barium hydrate in a tank, the salt readily dissolving and a small single-acting plunger pump forcing the solution into the feed-water pipe leading to the heater. The pump is run at a constant speed so that there is a constant injection of the solution.

We tried soda ash but found that it made a hard scale on the tubes. The barium hydrate is much better and effectively clears muddy water. Soda ash, if used too freely, is liable to cause foaming of the boilers. The quantity used is at the rate of 1 lb. to 2000 gal. of water. The sketch shows the method of using the solution. The barium hydrate is placed on the screen *B* and a small stream of hot water from the pipe plays on the lumps, dissolving and carrying them into the tank *C*. The solution is then drawn through the suction pipe *O* into the pump and discharged through a ½-in. pipe *E* into the water inlet pipe *F* and then into the heater *G*.



WATER PURIFYING EQUIPMENT

A. RAUCH.

Pittsburg, Penn.

Difficult Test Conditions

I recently had an experience which might not have been a problem for many engineers, but it kept me studying for several days before I hit upon an easy solution. I was asked to pass judgment on a second-hand boiler and wished to subject it to a hydraulic test, but a careful search throughout the town failed to reveal a pump that could be used to obtain the necessary pressure. Confident that I could devise some means to accomplish my purpose, I went forward with the work of inspecting the boiler and getting it ready for the test.

After blocking the boiler up so that the place where the gage was to be connected would be the highest, I filled the boiler with water until it ran out of the pipe on which the gage was to be screwed. The purpose was to drive out all the air possible. As the boiler was of the locomotive type and lay on its side there was probably a little air left in the dome. After screwing on the gage and closing every outlet tightly, I built a fire of light wood in the firebox and the expansion of the water quickly gave the desired pressure. A globe valve was provided to let out the water as soon as the right pressure was reached and the gage was watched carefully as the pressure rose rapidly when the water began to get warm.

In small towns it is especially necessary for an engineer to be resourceful and the genius often displayed by country engineers would greatly tax the ability of their better-paid brothers of the city.

G. E. Miles.

La Jara, Colo.

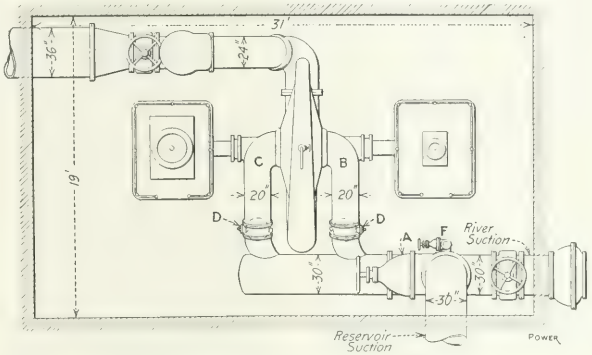
Centrifugal Pump Installation

The accompanying illustration shows the arrangement of a 25,000,000-gal. centrifugal pump direct-connected to a 14 and 30 by 24-in. cross-compound vertical Corliss engine. The suction and discharge pipes are so laid out that water may be pumped from the river to the settling basins, or from the basins to the high-pressure station located quite a distance from this plant.

In order that the pump may raise water from the river when it is at its lowest recorded level, it was placed at an elevation of 19 ft. above that level. As the highest recorded level is 29 ft. above the lowest, it was necessary in protecting the pump from being flooded, to construct a concrete wall entirely around it.

The conditions required that the pump be placed at right-angles to the suction and discharge pipes, and use a P double suction instead of the common Y-arrangement. The main suction was reduced to 30 in. and each run of the double suction to 20 in, with a 24-in. discharge. Usually the sizes are 36, 24 and 30 in., respectively. Butterfly valves *D* were fitted in each of the double suction pipes to equalize any unbalanced shaft thrust that would be caused by the uneven flow of water into the double suction pipes. It has not yet been found necessary to adjust these valves.

In the winter, when ice clogs up the screens at the intake, much air is taken into the pump with the water. Under such conditions, with a suction lift of 18 ft. at *A*, *B* will show 18 ft. and *C* 21.5 ft., depending upon the amount of air passing to *B* and partly destroying the vacuum.



Arrangement of Pump Engines and Piping

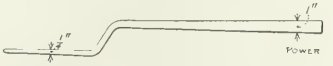
When the river is at its low level it is frequently impossible to obtain the suction by priming by means of the by-pass valve *F*, but by partly opening the main valve and starting the engine, suction is readily obtained. The reason for this is that the water supplied from the reservoir is insufficient for the speed of the pump and a vacuum is created in the suction which raises the check valve and allows air to enter.

Lawrence Kjerulff.

Kansas City, Mo.

Simple Valve Wrench

The accompanying illustration shows a simple valve wrench which may be made from an old file. Besides being used for opening and closing stubborn valves, it serves well to push packing into a stuffing-box.



Valve Wrench Made from a File

The amount of taper given to the wrench should be from 1 to ¼ in. for ordinary work. To work it, the wrench is inserted between the spokes of the valve wheel edgways.

J. S. Allen.

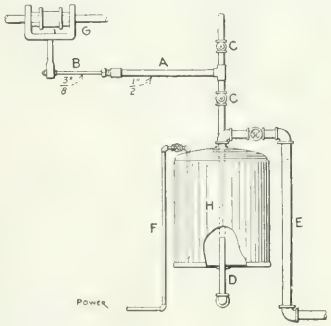
Santa Barbara, Calif.

Boiler Compound Feeder

The usual methods of feeding boiler compounds to the boilers are generally productive of poor results on account of the difficulty of maintaining the proper proportion of the compound to the water evaporated.

To obtain this condition and maintain it automatically we use the apparatus shown in the accompanying illustration.

The pump *A* is made of ½-in. pipe and fittings and a brass stuffing-box drilled to take the ⅜-in. plunger *B*. Two ½-in. check valves are placed at *C* on the suction and discharge pipes. The suction enters the bottom of the compound tank *H*, extending for about 6 in. into it as shown at *D*. A ¼-in. steam line containing a valve *F* runs over and into the tank for the purpose of agitating the fluid. There is also a ¾-in. water-supply line *E* to which are attached a valve and float, not shown in the illustration; the level of the fluid is thus automatically maintained.



Boiler Compound Feed Pump

The required amount of compound is placed in the tank every six hours. As the fluid pump is operated by the crosshead *G* of the boiler-feed pump and discharges into the suction of the latter, the right quantity of compound is always fed to the boilers.

Tipton, Calif. B. F. Hartley.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Should an Engineer Purchase Instruments?

Of course the question as to how much an engineer should spend for instruments used in power-plant practice will long remain an open one because it is a matter of personal opinion influenced by the size of the individual's pocketbook.

However, the man purchasing an indicator, Orsat and other apparatus is usually well compensated. The experience gained by their use not only better fits a man for conducting his own plant economically, but he might possibly make some money in doing test work on a small scale. His only requirement is the time necessary to do the work.

J. C. HAWKINS.

Hyattsville, Md.

Two Kinds of Avoidable Explosions

Here is an instance of a third kind of avoidable explosion that may be interesting in connection with the editorial under the above heading in the Apr. 23 issue: Two engineers, in different parts of Sandusky County, attempted to clean soot from the tubes of upright boilers by throwing a pound of gunpowder in the firebox. The report as to the efficiency of this method is incomplete. The tubes remained, but the men went into the hands of physicians for repairs and treatment.

E. STANLEY THOMAS.

Fremont, Ohio.

What Causes the Sediment

Referring to W. V. King's inquiry in the Apr. 30 issue, I would infer that the water used contains ferrous salts in solution. This can be tested by dissolving a little potassium ferricyanide (K_3FeCN_6) in distilled water, and adding some of the suspected water to it. A blue precipitate shows ferrous salts in the surface water.

If this reaction proves the presence of ferrous iron, it can be taken out by treatment in open tanks with either lime or soda, or even better, if the amount is small so that the expense is not prohibitive, by sodium peroxide; 1 gr. of sodium peroxide is equivalent to 5.8 gr. of ferrous sulphate or 2.1 gr. of metallic iron.

DONALD M. LIDDELL.

Elizabeth, N. J.

Soda for Cleaning Lubricators

The many lubricator experiences related in past issues call to mind a method I use to improve the feeding of the oil. When the feed is not steady and there is an accumulation of oil in the sight-feed glass, the use of soda will correct the trouble. I put in a pinch of soda and allow it to settle to the bottom of the glass.

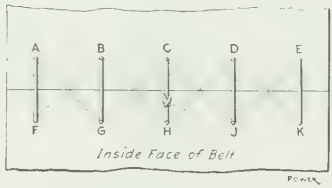
JOHN YOUNG.

Utica, N. Y.

Belt Lacing

In the issue of Apr. 16, Mr. Fries has written a very interesting letter about wire lacing and my experience confirms all that he has said in favor of it. I have found, however, that the method described by him has a tendency to throw the end of the belt out of line, particularly when the belt is subjected to sudden strain. To overcome this, many engineers use a form of lacing that makes the lateral stress equal in each direction, and the joint is strong and very satisfactory under the most severe conditions.

To lace a belt in this manner, use a



SHOWING METHOD OF LACING

piece of lacing wire whose length is about ten times the width of the belt, and locate the middle point of the wire. With the end of the belt squared and the holes marked, begin by drawing the wire up through *C*, as shown in the illustration, and down through *H*, pulling the wire until the middle point is between *C* and *H;* then carry the end of the upper section of the wire up through *G*, down *B*, up *F*, down *A*, up *F* again, down *A* again, up *G*, down *B* and up *H*. This will complete one-half of the joint. With the other end follow the same plan in holes *D*, *E*, *J* and *K*, thus completing the second half of the operation. The two ends will now be at holes *C* and *H* of the outside face of the belt. They should be twisted together and pounded into the leather with the rest of the lacing.

To those who have never made a wire joint, I would say that after the ends of the belt are squared, a line should be drawn parallel to the end edge and about $\frac{1}{16}$ in. more than the thickness of the belt back from the edge. Such a line would join *A* and *E* of the illustration. The holes should be marked off on the line with a pencil; the ends of the wire may be filed to a point to facilitate their entrance into the hole. It is better to make the holes as they are needed rather than make all of them before starting because the holes will close up some as the belt is handled, thus making it difficult to push the ends of the wire through the holes. A handy awl may be made by taking a 4-in. piece of round steel wire tempered and ground to a point and inserting it in a handle.

A wire-laced joint is not as good as a cemented one, but it has these advantages: it can be made quickly, and when made properly it will run as smooth as any part of the belt.

W. G. HAWLEY.

Clark's Summit, Penn.

Chimney for Dissipating Smoke

A newly patented chimney for dissipating smoke was described by Dr. Alfred Gradenwitz in the Apr. 2 issue; it seems to me nothing more than a clever contrivance to outwit the smoke inspector.

The chief damage from smoke is the minute particles of carbon which settle over the surrounding territory. If an ordinary chimney scatters this carbon for a mile and the dissipator scatters it twice as far, it would be a good thing for the people near the plant and a poor thing for the residence property further away. In a city with a chimney every half mile or so apart, what will be the result?

We have a smoke dissipator in our plant, but never had it patented. Our smoke inspector is rather strict, and as we have a few barrels of sawdust to dispose of every day and it creates much smoke, we got a notice from the smoke inspector. Since then we have dissipated the smoke by burning it after dark with very good results—to our company.

JOHN BAILEY.

Milwaukee, Wis.

Barometric Condenser in Turbine Practice

In the description of the pumping plant at the Sloss Iron Mines in the Apr. 9 number the turbine is shown connected to a barometric condenser and the exhaust pipe has a drop leg in it where it comes from the under side of the turbine and runs horizontally to the riser in the condenser.

In the above installation I have no doubt that this is properly drained, but I once operated two turbines with the same arrangement which ran on widely varying loads.

On the bottom of the horizontal pipe there were two 2-in. outlets with a gate valve and swing check valve connected to each. When warming the turbine all of the condensation ran out by gravity before the condenser was thrown into operation and when the vacuum began to rise the check valves closed automatically and were kept closed by the atmospheric pressure; in the same way, when the turbine was stopped, they opened again.

As will be seen, these drips were useless when there was a vacuum existing in the exhaust pipe, so that if a large quantity of water flowed in, the drips did not protect the machine.

It was necessary to run one of the turbines continuously, and on days when but little power load was needed, the load dropped as low as 50 kw. Under a 28-in. vacuum the exhaust pipe became quite cool almost up to the turbine, and what little steam was flowing through condensed and left the water in the drop leg. Here it accumulated until the pipe was nearly full, when a slight clicking was heard in the riser which increased as the amount of water increased. Then it was necessary to break the vacuum when the check valves opened and allowed the water to run out. This caused two serious accidents in this plant, one when the exhaust pipe was cracked and one when the water surged back into the turbine wheels and tore out a large number of the blades. Thereafter, the operators looked out for the trouble and checked it in time to avoid any accidents, but if they waited too long there was a heavy rumbling noise and water flew out at the relief valve. During heavy loads no trouble was experienced as there was steam enough flowing to prevent any condensation in the exhaust pipe.

This form of condenser is the only one where the piping should have a drop leg or pocket where water can accumulate; with the surface or jet type the turbine can be located above the condenser and all condensation will flow into it.

In this instance, the chief engineer tried to have an apparatus installed which would take care of the water at any time. All such exhaust pipes, whether they are on an engine or turbine, should be fitted with a vacuum trap which automatically admits steam and discharges the water as fast as it accumulates. Such a trap in the plant mentioned would have well paid for itself.

G. H. KIMBALL.

East Dedham, Mass.

Asbestos Drum Covering

Mr. Koppel's letter under the above title in the Apr. 9 issue brings to mind a similar experience I had in covering the bottom of a receiver with asbestos. I did not think of the method Mr. Koppel used, but I finally succeeded in making the asbestos stick to the receiver.

After about two hours of hard work and nothing accomplished, I decided to try applying ordinary red clay, mixing it with water to the consistency of house paint and using a brush to apply it. It proved successful as the receiver was hot and the clay dried quickly. After giving the receiver two coats of clay, the asbestos was put on with a trowel.

J. W. DICKSON.

Memphis, Tenn.

Water Gage Illuminator

While I agree with Mr. Dixon's comment under the above heading in the Apr. 2 issue, that the use of a mirror behind a water gage-glass is not to be recommended, I do not agree with some of his other statements.

Mr. Dixon should remember that a glass does not always remain clean, and that the reading of the water level is thereby made difficult as the glass becomes more cloudy. To facilitate the reading under such conditions I use a white strip of paper mounted on a board which is hung back of the glass; an electric light is also hung near the glass, and is protected from breakage in case the gage-glass is blown out.

WILLIAM E. DIX.

Los Angeles, Calif.

Benefits of Mutual Aid

Too much prominence cannot be given the thought expressed in the foreword in the issue of Apr. 2, "A man cannot turn anything over in his mind unless he knows it."

The policy adopted by a great many chief engineers, foremen and master mechanics, of keeping down and neglecting to instruct the men under them, is absolutely criminal and should be condemned in the strongest terms. I have often heard foremen complain that they were not going to tell the men under them everything they knew, and make them capable of taking their jobs.

This shows how narrow-minded some men are. By instructing their assistants properly, they would make their own work lighter and easier. They would be accomplishing some good in the world other than working just to live, and would advance to a certain extent the engineering knowledge. So give the cubs a chance, help them all you can; we were all cubs once, and no doubt all of us appreciate a helpful word. The cubs of today will be the leaders of tomorrow.

A. RAUCH.

Pittsburg, Penn.

Cold Air and Leaky Pipe Joints

I do not agree with some of L. J. Ollirer's statements in the Apr. 2 issue. If steam pipes are properly installed and allowance is made for expansion and contraction, the joints should not leak even if exposed to severe cold air currents. In many plants steam is turned on and off the lines frequently and the resultant contraction and expansion cause no leaks.

If the flanges are brought in line with each other and are free from pits and dirt, and a good grade of packing is used, there is no reason for leaks due to cold air currents striking the piping. Any joint not properly put up will leak in time.

JOHN THORN.

London Junction, Ont.

I am sure cold air causes leaky joints. In our plant we have a steam turbine, and from where the main steam line connects on the separator to the wheel case there are eight flanged joints. If the windows are left open in cold weather the joints begin leaking and will continue to do so until the windows are closed. A good grade of packing is used.

W. N. BEHEN.

Bilington, W. Va.

Pump Would Not Force Water

In regard to J. W. Dickson's letter in the Apr. 23 issue as to why the raising of the suction pipe caused the water to flow, there seems to be but one good reason.

Probably if the suction strainer had been examined in the first place it would have been found to be imbedded in the mud. Raising the pipe 4 in. lifted it out of the mud and allowed the water to flow.

It is possible, too, that the elbow directly below the pump leaked air, and by raising the pipe line the threads were tightened and the leak stopped. The admission of air at that point would, of course, break the suction.

There seems to be no other reason for the pump's failure; in fact, the new position of the suction pipe apparently

precludes successful operation, as there is an excellent opportunity for the formation of an air pocket in the suction line. A glance at Mr. Dickson's sketch will make this evident.

GRANDON D. GATES.

Seneca Falls, N. Y.

Value of a CO_2 Recorder

Judging from Mr. Franklin's comment, in the Apr. 16 issue, under the above heading, on my letter in the Feb. 13 issue, he apparently belives that I am not in favor of flue-gas analysis, he probably has this impression because I failed to clearly express myself.

While I consider flue-gas analysis necessary to the efficient management of a plant, I also contend that it is a mistake to set too high a standard and hold the firemen to it. It is better to keep from the men the fact that there was a standard; they would then have no reason to cheat. The engineer would then be able to discover and remedy faults in boiler settings and furnace construction, have a check on the fireman, be able to instruct him when necessary, and so gradually bring the men and the plant up to real efficiency.

By setting too high a standard and saying, "It's this or your job," the men are given a motive to cheat, as then the job is of greatest importance. On the other hand, by setting too low a standard, the average fireman will think that when he has attained it he has done enough, and will make no effort to do better. A faked sample is worse than no sample at all.

I agree with Mr. Franklin that 16 per cent. of CO_2 is unusually high, but we got it where one of the boilers was in a battery, and the partial closing of the damper necessary to get a high percentage did not materially affect the total output of steam. Also, one man gave his whole attention to that boiler, and tried to get the highest possible CO_2. These conditions are absent in everyday practice, and I would not stake anything on getting 16 per cent. from this boiler under everyday conditions. If the dampers on an entire battery are only slightly hauled, it would cause a drop in the steam pressure. The fireman in the average plant also has his boilers and boiler room to keep clean, and has to assist the engineer at times; he cannot give his boilers the attention necessary to get as high a percentage as 16.

The percentage of CO_2 in small boilers is apt to be lower than in large ones because the smaller fire requires more frequent attention than the larger one, and frequent opening of firedoors admits an excessive amount of air.

In a coal-burning plant with average firemen, 10 per cent. CO_2 is a good average. I have averaged 12 per cent., but it required my entire attention in the fireroom watching the men and "jockeying" the dampers, besides keeping an eye on the stack for smoke.

I cannot tell Mr. Franklin why 11.5 per cent. was used as a standard; I was told to obtain it. Personally I consider it a little too high. In the plant discussed an analysis of the flue gases is made at the end of each watch, and sampling bottles are used instead of a recorder.

A. POHLMAN.

Brooklyn, N. Y.

Wavy Expansion Line

J. W. Dickson's letter and illustrations under the above heading in the Apr. 16 issue are very interesting.

Referring to Fig. 5, I think the pipes from the angle valves to the three-way cock are too large, as they form a condensing chamber, and when the valves are opened the clearance space is increased considerably. The nipples attached to the cylinder at the clearance space cannot be greater than the usual ½-in. size; therefore I should have continued the ½-in. pipe to the three-way cock.

It appears that a light load was being carried when diagram Fig. 3 was taken, but either a higher steam pressure or a lighter load would make a difference in the expansion line. I believe that condensation in the 1½-in. pipe was the cause of the wavy expansion line in Fig. 2. It has also been my experience that long indicator piping has a tendency to conceal defects rather than disclose them; therefore the connection should be as short as possible to obtain a true diagram.

LEIGHTON JOHNSON.

Exeter, N. H.

The Three Pressure Problems

Answering Mr. Hawkins' pressure problems in the Mar. 26 issue, I submit the following:

1. There is water inside of the spring of a steam gage, and when the gage is first applied to the boiler the spring is of course full of air at atmospheric pressure. On the pressure being raised in the boiler this air is compressed into a small volume, the volume depending upon the pressure in the boiler. In time this air will be absorbed by the water formed in the siphon, to which the gage is attached.

2. The gage will show the same pressure as that on the boiler. I know of such an installation in which there are 200 ft. of ¼-in. pipe between the gages, and the distant gage indicates the pressure accurately.

3. The friction in the pipe would not affect the pump so that no water would be discharged. Friction depends upon the velocity of the water as well as the length of the pipe, and the effect of lengthening the discharge pipe would be to increase the head on the pump and thus reduce its speed and capacity. To prevent any discharge, the static head must be increased so that the pressure on the plungers will balance the pressure on the pistons.

If lengthening the horizontal run of discharge pipe in this case would prevent the discharge of the pump, the distant gage of question No. 2 would show a reduced pressure.

C. O. SANDSTROM.

Kansas City, Mo.

1. If the gage is connected with a coil or siphon between it and the boiler, as most gages are, the spring is filled with air. Water condenses and collects in the coil, forming a water seal which keeps the steam out of the gage. The air in the gage will maintain a lower temperature than the steam, thereby lengthening the life of the gage.

2. The gage on the boiler and the one at the end of the pipe should show the same pressure. This is true only when there is no flow in the pipe from leaks or steam being taken off by branch lines.

3. No matter how long the pipe is, there will be a flow of water through it so long as the total lift remains constant. The friction losses in the pipe and at the discharge can be expressed by the formula

$$f = m\frac{v^2}{g}$$

where

f = Loss due to friction (feet head);
m = Constant depending upon size of the pipe;
v = Velocity of the water
g = 32.2 (acceleration due to gravity).

By making v very small, f is small, so that the head pumped against is really only a little over 10 ft. The velocity will automatically adjust itself to the friction head and the head due to the 10-ft. lift and the pressure produced by the pump.

EARL S. RUSH.

Lawrence, Kan.

Water Tank Gage

Edward L. Johnson's water-tank gage, described in the Apr. 23 issue, could be improved by attaching a bell circuit with contacts on the indicator at the high- and low-water limits, with one wire connected to the rack and a small switch placed in the line.

A more convenient and less expensive method would be to install an altitude gage in the discharge line to the tank above the pump as it practically takes up no space and is more reliable. With a pump-controlling valve to control the action of the pump by the change in the discharge pressure, he would have a thoroughly automatic arrangement.

JAMES G. SHERIDAN.

Brooklyn, N. Y.

Inquiries of General Interest

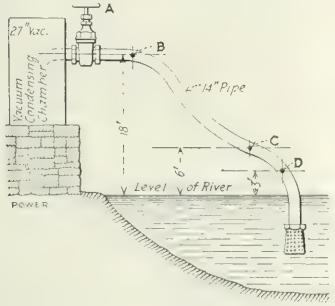
Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Pressure at Different Points Along a Pipe

What will a vacuum gage register when connected successively at points *B*, *C* and *D* of a pipe connected as in Fig. 1, the points for gage connection being respectively 18, 6 and 3 ft. above the level of the water of the river from which the supply is drawn, the injection valve *A* being wide open and the pipe connected to the condensing chamber in which a 27-in. vacuum is maintained, shown by the diagram?

W. J. H.

Neglecting the small siphoning effect due to turning down the end of the pipe



PRESSURE AT DIFFERENT POINTS ALONG A PIPE

after it has entered the condensing chamber, the variable density of the water while flowing through the pipe (due to liberation of air) and the very small difference of gage reading that would result from attaching the gage above or below the center of the pipe, the pressure indicated by the gage placed at *B* would be the same as the pressure in the condensing chamber, 27 in. vacuum.

Placed at *C*, the gage would indicate the same pressure as at *B* less the downward pressure per square inch, which would be due to a column of water having a head equal to the difference of elevation of the points *B* and *C*; that is,

$$18 - 6 = 12 \text{ ft.}$$

As each foot of column of water exerts the same downward pressure per square inch as a column of mercury 0.8832 in. high, the downward pressure per square inch due to the 12-ft. column of water is the same as that due to a column of mercury,

$$12 \times 0.8832 = 10.6 \text{ in.}$$

Therefore, when placed at *C* the gage would indicate

$$27 - 10.6 = 16.4 \text{ in.}$$

vacuum.

In similar manner, with the difference of level of 15 ft. between the points *B* and *D*, there is a downward pressure at *D* due to the head of water from the level of *D* up to the level of *B*, which is equal to a column of mercury 15×0.8832 in. high. As this is equal to the downward pressure of a mercury column 13.25 in. high, the gage placed at *D* will indicate

$$27 - 13.25 = 13.75 \text{ in.}$$

of vacuum.

Feasibility of Running Condensing

How much water at 55 deg. F. will be required for a jet condenser used with a 19x42-in. Corliss engine making 78 r.p.m.? The engine running noncondensing is so overloaded that frequently it will not cut off for three revolutions out of five for two hours at a time. What will be the temperature of the water discharged from a jet condenser? The condensing water would have to be raised about 50 ft. The only water supply available is now used for factory washing purposes, which could be continued provided the temperature was not excessive. Could the exhaust steam be carried through a closed heater before passing to the condenser? Some of the exhaust is now used for warming buildings with 3 lb. back pressure on the engine. Would it not be more economical to warm the buildings with live steam?

What would be the advantage of installing a jet condenser under the conditions stated, assuming that the water supply is sufficient? Of what advantage are two eccentrics on a Corliss engine?

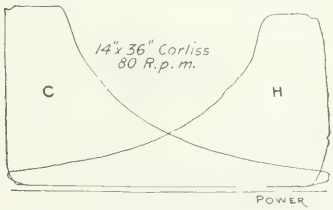
E. P. C.

About 25 times as much condensing water will be required as is needed for making the steam used by the engine. The temperature of condensing water leaving a jet condenser would be about 110 deg. F. The exhaust could be conveyed through a closed heater before going to the condenser.

The advantage of running an engine condensing will depend upon the cost of the water supply, the horsepower to be developed and the boiler pressure. The advantage of using live steam for warming purposes instead of exhaust with 3 lb. back pressure will depend upon the amount of steam required. If a large proportion of the exhaust can be used for heating and other purposes a condenser will not pay. A Corliss engine is operated with two eccentrics because an opportunity is thus afforded for adjusting the steam valves independently of the exhaust valves; an early release may be had without sacrificing compression, and the valve-gear will operate throughout a greater range of cutoff.

Late Admission

The late-admission diagrams herewith were taken with a 40-lb. spring from a 14x36-in. Corliss engine which makes 80 r.p.m. with 130 lb. boiler pressure.



LATE ADMISSION

What should be done to correct the late admission? The engine eccentric is keyed to the shaft.

E. P. F.

Adjust the length of the wristplate connections to the steam valves. It would be well, also, to close the exhaust valve on the crank end a little earlier by adjusting its connection so as to make the compression more like that of the head end, besides tending to equalize the size of the diagrams.

Determining Oil in Condensation

How can the amount of oil in return water from an exhaust-steam heating system be determined?

J. N.

A fair test of the amount of engine cylinder oil contained in a sample of condensation may be made by determining how much oil has to be added to a given quantity of fresh feed water, in order to cause the latter to present the same appearance of turbidity when equal quantities of each kind of water are mixed with the same quantity of any given solution of sodium hydrate (caustic soda). Care should be taken that all solutions are employed at the same temperature.

Study Questions

This Week's Questions
Last Week's Answers

11. A gasoline engine weighing 650 lb. is to be mounted on a concrete foundation 2 ft. high measuring on the top 2 ft. wide by 4 ft. long, and at the base 3 ft. wide by 5 ft. long. The sloping sides are flat and symmetrical; that is, the inclination is uniform, all sides making the same angle with the horizontal top. Required the total weight per square foot on the floor after the engine is in place, taking the weight per cubic foot of concrete as 125 lb.

12. A small power plant burned 56 tons of coal in the month of May. This was an increase over April of as much in per cent. as was burned in tons in April. What was the April consumption?

13. If a person is in a field of ice which moves west at the rate of two miles an hour, and he walks in a straight line at the rate of three miles per hour, in what general direction must he travel and how long will it take him to arrive five miles due north of his first position?

14. A ladder of uniform weight throughout, 30 ft. long, weighs 60 lb. and leans against a vertical wall, making an angle of 65 deg. 50 min. with the horizontal. A man weighing 150 lb. ascends 25 ft. on the ladder. Required the pressure against the wall.

15. The sum of the speeds of two pulleys is 110 r.p.m. One of the pulleys runs 100 r.p.m. faster than the other. What is the speed of each pulley?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

6. Assuming an ordinary 110-volt direct-current circuit, the actual drop in voltage between the switchboard and the load would be

$$0.03 \times 110 = 3.3 \text{ volts}$$

From Ohm's law

$$R = \frac{E}{I} = \frac{3.3}{320}$$

Where

R = Resistance in ohms;
E = Difference in potential; in this case the drop in voltage;
I = Current in amperes.

The resistance of 1 ft. of copper, 1 circular mil in section, is 10.8 ohms. As the resistance varies directly with the length of the conductor and inversely as the cross-section, the resistance of 700 ft. would be

$$R = \frac{700 \times 10.8}{A}$$

where A is the area in circular mils. Substituting the value of R from the previous equation

$$\frac{3.3}{320} = \frac{700 \times 10.8}{A}$$

$$A = \frac{700 \times 10.8 \times 320}{3.3} = 732{,}000 \text{ circular mils}$$

A 750,000-circular mil cable would be required.

7. The formula for a free fall in vacuo is

$$s = ct + \tfrac{1}{2} gt^2$$

where

s = Distance, or height in feet;
c = Initial velocity;
t = Time in seconds;
g = Acceleration due to gravity = 32.16 ft. per second.

Substituting the known values in this equation

$$493 = 50t + 16.08t^2$$

This is a quadratic equation solved by making the member involving the unknowns a perfect square by dividing through by the coefficient of t^2,

$$t^2 + \frac{50}{16.08} t = \frac{493}{16.08}$$

and completing the square by adding the square of half the coefficient of t,

$$t^2 + \frac{50}{16.08} t + \left(\frac{25}{16.08}\right)^2 = \frac{493}{16.08} + \left(\frac{25}{16.08}\right)^2$$

Extracting the square root of both sides

$$t + \frac{25}{16.08} = \sqrt{\frac{493}{16.08} + \left(\frac{25}{16.08}\right)^2}$$

$$t + 1.555 = \sqrt{33.577} = 5.794$$

$$t = 4.239 \text{ sec.}$$

8. One plant contained three full barrels, one half barrel and three empty barrels; the other two plants each contained two full barrels, three half barrels, and two empty barrels, making 3½ barrels of oil and seven barrels at each plant.

9. The valve is held down on its seat by the weight of the valve and valve stem (7 lb.) plus the downward pressure of the lever on the valve stem due to the weight of the lever

$$\left(\frac{42}{4} \times 14 = 147 \text{ lb.}\right)$$

plus the downward pressure of the lever on the valve stem due to the safety-valve ball or weight

$$\left(\frac{27}{4} \times 30 = 202.5 \text{ lb.}\right)$$

making a total of 356.5 lb.

The diameter of the valve being 3 in., it has an area of 7.0686 sq.in. exposed to pressure on the under side; therefore the valve will rise and blow off when there is a pressure on the under side of

$$356.5 \div 7.0686 = 50.43 \text{ lb.}$$

per square inch.

10. The discharge pressure 45 lb. per square inch is equivalent to

$$\frac{45}{0.433} = 103.92 \text{ ft.}$$

Subtracting this from the available head, 200 ft., leaves 96.08 ft. to overcome the friction in the pipe. The quantity of water discharged is 50,000 gal., or

$$\frac{50{,}000}{7.4805} = 6684.04 \text{ cu.ft.}$$

This being discharged in 10 hours,

$$\frac{6684.04}{10 \times 60 \times 60} = 0.1857 \text{ cu.ft.}$$

is discharged per second. The velocity through the pipe will be this last quantity divided by the area of the pipe, as yet unknown, but which may be expressed in terms of the diameter d in feet. Then

$$V = \frac{0.1857}{0.7854 d^2} = \frac{0.2364}{d^2}$$

Using Darcy's formula reduced to English measures, the friction head is

$$h = \left(0.0199 + \frac{0.00167}{d}\right) \times \frac{l}{d} \times \frac{V^2}{2g}$$

Substituting our known values,

h = 96.08 ft.;
l = 5280 ft.;
$2g$ = Twice the acceleration of gravity = 64.32;

$$V^2 = \left(\frac{0.2364}{d^2}\right)^2$$

$$96.08 = \left(0.0199 + \frac{0.00167}{d}\right) \times \frac{5280}{d} \times \frac{\left(\frac{0.2364}{d^2}\right)^2}{64.32}$$

which reduces to

$$6179.8656 d^5 - 5.8735 d - 0.4920 = 0$$

By inspection it will be seen that d must be a fraction; hence the pipe will be less than 1 ft. in diameter. By trial it will be found that the equation is satisfied by some value of d between 0.25 and 0.03 ft. or between 3 and 3.6 in. The nearest commercial size is 3½ in., which is therefore the size pipe to use.

Japan Gold Size for Joints

By A. L. Haas

A jointing material of considerable value, not generally known, is Japan gold size, which is a liquid used by painters for a drier.

In connection with pneumatic plants it can be used successfully and for compressor cylinder joints made with brown paper it has proved superior to the ordinary red lead and boiled-oil paint.

The material is sold by paint dealers everywhere and has good keeping qualities. Upon exposure to air it dries rapidly, forming a tenacious, adherent, transparent coating.

Unfortunately the writer has no data as to its behavior for joints having to withstand steam heat, but he sees no reason why it should not at least be tried.

Tricked the New Oiler

By E. M. Keys, Jr.

Dick, who was an old-timer with the oil can, was showing a young oiler the "ropes," who when he saw the automatic engine stop, promptly wanted to know what it was.

Dick told him that it was the "butterfly" and that it must always be kept cool; otherwise the engine would "go on the blink." After the boy had been oiling around for a while he thought he would feel the "butterfly." Of course, it was hot, and he lost no time in telling Dick that the thing was going to pieces.

Dick told him to hurry to the boiler room and get a sack of "vacuum" and be quick about it.

The oiler hurried up the stairs to the boiler room where Bill, the water tender, asked him what was the trouble. The kid said that No. 1 engine was burning up and he wanted a sack of vacuum, quick.

Bill went to a corner and dragged out a 100-lb. sack of portland cement and told the kid to make haste. Arriving at the engine room, Dick told the kid that he had the wrong sack as it was too coarse, and to take it back and bring a sack of fine vacuum.

The oiler struggled back to the boiler room, where he was again met by Bill, who asked what was wrong. The kid explained and another sack of portland cement was dragged out.

The kid picked it up and when half way down the stairs, puffing like a locomotive on an up-grade, and nearly all in, he was met by the chief, who wanted to know what he was in such a hurry about with that sack of cement. The kid explained, and the chief, with a snort, ordered the kid to take the cement back to the boiler room where it belonged and get busy with his oil can.

That Dick and Bill got a reprimand from the chief goes without saying, and while they enjoyed the joke they nevertheless took care to avoid the new oiler for several days.

A total storage capacity of 360,000 tons of coal is provided by the Lehigh Coal & Navigation Co. at its plant at Hauto, Penn. The plant is electrically operated throughout, and has four pivoted reloading machines, their combined capacity being 8000 tons per 10-hour day.

Reduction of Edison Rates in Brooklyn

The Brooklyn Edison Co. has just announced a reduction in its rates and a change in the system of charging which will become effective July 1, 1912. The present rate for retail lighting is 12c. per kilowatt-hour, and it is this class of consumers that is most affected by the change. At present there are three forms of contract, known as retail, intermediate and wholesale; there is also a special wholesale contract under which the guaranteed minimum is $3000 per year.

The new rates, however, are based on the maximum-demand plan. The highest rate will be 11c. per kilowatt-hour for the first two hours of average daily use of the maximum demand; for the third and fourth hours the rate will be 8c. per kilowatt-hour, and for all service in excess of four hours' average daily use of the maximum demand the rate will be 4c. per kilowatt-hour. The minimum bill will be $1 per month.

The maximum demand, except when otherwise requested by the customer, will be computed as a percentage of the connected load. For residences the maximum demand will be taken as 50 per cent. of the connected load, and for all other premises 70 per cent., each standard socket being rated at 50 watts. As an alternative, every customer has the privilege of using a demand meter to register the maximum demand, for which there will be an additional charge of $1 a month. Under the special wholesale contract the guaranteed yearly minimum will be reduced from $3000 to $2400, billed at $200 per month.

University of Wisconsin Extension Courses

A Wisconsin law will shortly make a youth's education compulsory up to the age of 16; then he may be apprenticed to a manufacturer who will agree to teach the boy the whole trade. The maximum working hours are 55 a week, five of which must be devoted to instruction in English, citizenship, business practice, physiology and such other subjects as are approved by the State Board of Industrial Education. The instruction may be given in a public school or in such other place and manner as may be approved by the board. Failure to attend will subject the apprentice to a loss of compensation for three hours for every one he is absent without cause.

In anticipation of this law, the University of Wisconsin has established courses in Milwaukee and several of the large manufacturing companies have promised to give some of their employees the necessary time off and allow them full pay.

In some cases the students come to the class rooms of the university and in others the instructor goes to the company shops where the students assemble in a room set apart for them. The subjects now being taught are shop mathematics, drawing, safety devices, English, citizenship, physiology and hygiene. These courses are only a small part of the university extension work which covers science, literature and the arts, as well as commercial, industrial and engineering work. Instruction is carried on by correspondence, class work and by a combination of both.

This year there are 67 class periods and about 1500 students, the bulk of the students being in the commercial, industrial or engineering courses, in charge of K. G. Smith, assistant professor of mechanical engineering.

Newark's Industrial Exposition

A very successful industrial exposition was held in Newark, N. J., in the First Regiment Armory under the direction of the local Board of Trade, from May 13 to 25. Among the exhibits were a number of engineering interest.

The Crane Co. displayed its full line of Cranetilt traps and valves for all purposes, and its rubber and composition sheet packing. The traps were shown doing actual service under and against compressed air, steam not being available. This company's new regulating valve was also exhibited. Adjoining the Crane booth was shown the Lambert Hoisting Engine Co.'s line of steam and electric hoisting engines and machinery. Further down the room the A. & F. Brown Co. displayed its line of pulleys, pinions, gears and bearings.

Directly across the aisle the Dixon Cascade Pump Co. drew much attention to its small centrifugal pumps, many of which were used by exhibitors for pumping purposes, among them, Ballantine Bros., brewers, who showed their product running from an inverted bottle suspended by a fine wire. The tube discharging the beer entered the neck of the bottle, and as the liquid ran out the tube was concealed, making it appear that the supply was inexhaustible.

The Eastwood Wire Manufacturing Co. displayed brass and bronze valves of all kinds. Nearby, the Watts-Campbell Co. had one of its 150-hp. Corliss engines belted and motor driven. Across the way were examples of the work of the Newark Central high-school pupils; a complete telephone central station of their own construction excited widespread interest.

Among other electrical exhibitors the General Electric Co. showed a full line of electrically heated chafing dishes, smoothing irons, radiators, disk stoves, glue pots, coffee percolators, toasters, cigar lighters, etc. The application of motor drive for devices used in hotels, restaurants, etc., included everything from an ice-cream freezer to a dough mixer. There were many fans and ozonators, and the lamp display was interesting in that the current consumed by the old Edison carbon and the new Edison Mazda lamps was metered as they burned side by side, showing the great economy of the Mazda. The General Electric Co. also displayed a color-matching outfit, consisting of an arc lamp fitted with a color screen which

removes the excess red, orange and violet, giving a spectrum which is closely like that of daylight.

The Westinghouse Co., in the next booth, showed its single, polyphase and prepayment watthour meters, a variety of alternating-current switchboard meters, power factor and frequency meters, and its 7-in. synchroscope; rectifier outfits for charging automobile batteries, lamps of all kinds, a number of small motors and a motor-driven eraser for use in the drafting room, were also shown.

The Crocker-Wheeler Co. had a large exhibit of its products, including a motor-generator set which supplied current to many booths; Remek lighting transformers, squirrel-cage induction and adjustable-speed motors, crane and rolling-mill motors and hoisting machinery.

The Bell Electric Motor Co. had an exhibit and demonstration of its single-phase motors equipped with a short-circuiting device which causes the machine to run as an induction motor after full speed is attained. The variety of goods shown by the Newark Electrical Supply Co. was very complete.

Ohio Society of Mechanical, Electrical and Steam Engineers

The above society responded to an urgent invitation to hold its spring meeting this year at Pittsburg, Penn., where, notwithstanding the limitations of its title, it has many members. The meeting, which was held on May 16 to 19, quite justified in interest and attendance this extra state excursion.

The first session was held at the rooms of the Engineers' Society of Western Pennsylvania, where, after an informal reception by the Pittsburg engineers, the visitors were welcomed to the city by Charles H. Garlick, the newly appointed chief boiler inspector of Allegheny County. Frederick W. Ballard, engineer of construction for the municipal electric-light plant of Cleveland, responded for the society. E. A. Uehling, of the Uehling Instrument Co., presented a paper upon the "Combustion of Coal in Relation to Boiler Economy"; and Ralph Beman, director of technical publicity for the National Electric Lamp Association, one upon "Modern Incandescent Lamps; Electrical, Photometric and Economic Characteristics." At another session, Francis Gangl, electrical engineer, Northern Ohio Traction & Light Co., read a paper on "Transformers and Transformer Connections Frequently Met in Practice."

Pittsburg offers generous opportunities for the entertainment of such a party and excellent use was made of them by the local committee under the chairmanship of William R. McCord, of the *Industrial World*.

On Thursday afternoon a visit was made to the Pittsburg testing station of the U. S. Bureau of Mines, where, among other interesting things, a convincing demonstration of the explosibility of coal dust was given upon a large scale.

After the adjournment of the evening session an "owl party" visited the Phipps power plant, where Chief Engineer John Hyde demonstrated his method of burning powdered coal in quite a different manner from that which had been seen in the afternoon at the Bureau of Mines. It is no reflection upon the powdered-coal demonstration nor upon Pittsburg to announce that the party adjourned to the Natatorium and took a midnight plunge in the swimming pool.

Following the Friday morning session, the visitors lunched with the students of the Carnegie Technical Schools, and visited the laboratories. The baseball game, which was scheduled as a part of the afternoon's program, being postponed on account of the weather, the company divided into parties and visited several of the local industries, including the Mesta Machine Co.; the Rankin plant of the McClintic-Marshall Construction Co.; the Jones & Laughlin Steel Co., and the Westinghouse Machine Co. The University of Pittsburg and the handsome power plant of the Carnegie Institute attracted many visitors.

On Friday evening, after a complimentary dinner at the Hotel Schenley, the visitors were taken to the theater. On Saturday there were further visits to industrial plants and other points of interest and the baseball game, without which a Pittsburg entertainment would be as naught, in the afternoon.

For the ladies, of whom an unusually large number attended, there were provided trips to the Allegheny Observatory, the Carnegie Institute Museum and Art Galleries, the Margaret Morrison Carnegie School for Women, the H. J. Heinz Co.'s plant, the Penns ·ania College for Women, etc., as well as automobile rides about the parks and city.

The fall meeting must be held in Ohio and in November. The selection of the city was left in the hands of the council.

National Gas Engine Show

The National Gas-engine Show, which will be held in Milwaukee, Wis., on June 17 to 22, under the auspices of the National Gas Engine Association, promises to be an exhibition which for the first time will be entirely devoted to the gas engine.

At the entrance to the Auditorium will be the exhibits of three large tractor companies, with the engines in operation. Gas and gasoline engines of various types for farm, marine, electric-lighting purposes will also be displayed, as well as dry batteries, magnetos, lubricators, clutch pulleys, spark plugs, etc.

At this exhibit the visitors will see as nearly as possible the actual operation of the engines and accessories as in ordinary service and run on their usual fuel.

During the show the National Gas Engine Association will hold its semi-annual convention; the meetings will be open to visitors.

Applications for space and further information should be addressed to O. C. Parker, president, National Gas Engine Association, La Crosse, Wis.

SOCIETY NOTES

The summer meeting of the American Society of Heating and Ventilating Engineers will be held in Detroit, Mich., on July 11 and 12, the details of which will be announced in an early issue.

The monthly meeting of the American Society of Engineer Draftsmen, held on May 16 in the Engineering Societies Building, was marked by the admission to junior membership of Miss Marie Oberlander, a student of architectural drawing at Teachers College, Columbia University. Miss Oberlander is the first woman to be elected a member of the society. The guest of the evening, F. F. Hickel, M. E., consulting engineer of Henry R. Worthington, delivered an interesting and instructive lecture on "Practical Applications of the Slide Rule." A paper by R. E. Boehck, a member of the society, of Evansville, Ind., on "The Development of Logging Machinery" was read and discussed.

PERSONAL

S. G. Pollard has resigned his position as mechanical engineer of the Cincinnati Water Works.

J. B. Merriam, of the Bruce-Macbeth Engine Co., Cleveland, Ohio, recently lectured on gas-engine construction and operation before the Sheffield Scientific School of Yale University. Various details of construction and plants in operation were illustrated by lantern slides.

E. J. Clarke has been appointed superintendent of the inspection department of the Casualty Co. of America, New York City, succeeding E. R. McAlenan. Mr. Clarke was formerly chief inspector of the Pennsylvania Casualty Co. and with the Hartford Steam Boiler Inspection & Insurance Co.

Orrin C. Lawrence has been appointed superintendent of the steam-boiler and flywheel department of the Globe Indemnity Co., New York. Mr. Lawrence has for several years been with the Hartford Steam Boiler Inspection & Insurance Co. and is regarded as one of the best posted men in the boiler business. He will assume his new position about June 1.

POWER

Vol. 35 NEW YORK, JUNE 4, 1912 No. 23

A Fellow Engineer's Advice

IN a recent issue of POWER we hear the old cry of engineers being underpaid. Especially among the old timers there also appears to be a prejudice against college graduates who are rapidly filling positions formerly held by practical men. Why this condition exists is evident to anyone who has noticed the development of power plants during the past few years. The plant owner of today will not pay a good salary for the old rule of thumb methods which answered some years ago. He can get a college man with scientific training who may lack practical knowledge at first, but is likely to lower the plant's cost more than enough to offset this.

Now instead of howling about the pay and carrying a chip on our shoulder for the collegian to knock off, it appears to me that we had better get busy and equip ourselves with the knowledge that will enable us to command better pay and hold our own with the college graduate. Most employers, if properly approached, will pay a man his price if it is to their interest to do so. It is up to us to show him just where and how it is and we must prove conclusively with facts and figures, not mere words, that they are not wasting but saving money.

On this page in the last issue we urged the college graduate to enter the power plant as the best place to get the training and practical experience he needs. Until he does this the practical engineer has the advantage of him. That many are now doing this seems to be taken by some operating engineers as cause for alarm—a menace to their welfare.

Such is not the case, for, as we have said, the operating engineer can easily hold his own if he is equally ambitious and improves his opportunities to add to his theoretical knowledge by study and experimentation.

A letter recently received from an operating engineer takes such a sensible view of the situation regarding the college man's entering his field, and the duties of engineers to their employers, that we print it here in full.

Many owners of today are getting acquainted with the indicator and some can take and read the diagrams although they are not engineers. This type of owner naturally expects his engineer to do the same. In fact every engineer should be master of the indicator, but unfortunately many are not. The same is true of combustion and flue gas analysis. Modern boiler plants are no longer run on guess work. Scientific management replaces rule of thumb methods. Efficiency is the watch word.

Lack of financial means is no longer a bar to the man who makes up his mind to acquire knowledge. There are numerous ways of acquiring the knowledge which will, if he persists, enable him to command a better salary and which will eventually raise the standard of the engineer at large. There is always work for the man who is above the average. It's the average man that suffers.

Calculating the Flow of Water in Pipes

By T. W. Holloway

General formulas with illustrative examples for the velocity of flow, quantity of discharge, head required to produce a given delivery, diameter of pipes to meet specified conditions and the comparative flow of water in pipes of different sizes.

In power-plant work, hydraulic problems are continually coming up and the engineer is frequently called upon to make calculations pertaining to the flow of water in pipes. This is a subject which can be made very extensive, especially where accurate results are required, but for practical calculations, such as are usually required around the power house, it is not necessary to go into a deep theoretical study of the subject.

The quantity of water passing any section of a pipe of uniform diameter in a given time will depend upon the cross-sectional area of the pipe, and the velocity at which the water is moving.

Let

a = Area of cross-section of the pipe in square feet;

v = Velocity of flow in feet per second;

q = Number of cubic feet of water passing a given section in one second;

then,

$$q = a v$$

For example: If water is flowing through a 6-inch pipe at the rate of 10 feet per second and the quantity delivered per second is required, it is necessary only to multiply the area of the cross-section of the pipe by the velocity. The area of a pipe is

$$\tfrac{1}{4} \pi d^2 = 0.7854 d^2$$

where d = the diameter of the pipe in inches. Therefore, the quantity in cubic feet passing a given section is

$$q = 0.7854 \times (\tfrac{1}{2})^2 \times 10 = 1.963$$

or approximately 2 cubic feet per second. If the quantity is desired in gallons, then multiply the discharge in cubic feet by 7.48. If it is desired to reduce gallons to pounds, as is sometimes necessary, multiply the discharge in gallons by 8⅓. To reduce cubic feet to pounds, multiply by 62½.

The theoretical velocity—that is, the velocity the water would have if there were no resistance due to friction in the pipe, resistance of bends, valves, etc.—would be the same as the velocity the water would attain in falling through a hight equal to the head. Expressed as a formula,

$$v = \sqrt{2gh}$$

in which

v = Velocity, in feet per second;

g = Acceleration due to gravity = 32.16;

h = Head, in feet.

By the head, which causes the flow, is meant the difference in level from the surface of the water in the reservoir to the center of the outlet, when the discharge occurs freely into the air, as shown in Fig. 1.

The theoretical velocity may be quite different from the actual velocity if the pipe is of great length, or if there are bends or valves to increase the frictional resistance in the pipe; but the theoretical amount often serves as a guide in making calculations. Suppose that it is necessary to find the velocity of flow and the discharge from a 6-inch pipe when the head is 50 feet.

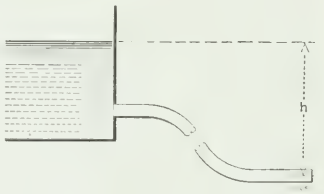


FIG. 1

$$v = \sqrt{2gh} = \sqrt{2 \times 32.16 \times 50} = 57 \text{ feet per second}$$

The quantity in cubic feet per second will be

$$q = a v = 0.7854 \times (\tfrac{1}{2})^2 \times 57 = 11.19 \text{ cubic feet}$$

Instead of the head being given in feet it is frequently expressed in pounds per square inch, as in the case where a head is furnished by a pump. This being the case, the head in pounds may be changed readily to head in feet by dividing by 0.434, or, what is the same thing, multiplying by 2.31. This is because a column of water 1 foot in hight exerts a pressure of 0.434 pound, or a column of water 2.31 feet in hight exerts a pressure of 1 pound.

If w represents the number of pounds of water discharged per second, the theoretical work which the falling water is capable of doing will be $w h$ foot-pounds, because work is the product of the force and the distance through which the force acts. In this case the force is the weight of water w, and the distance is the head h.

The kinetic energy of the flowing water is $\frac{w v^2}{2g}$, and if no work is expended in overcoming resistance due to friction or other losses, then the expression for work and for kinetic energy must be equal, or

$$w h = \frac{w v^2}{2g}$$

From which

$$h = \frac{v^2}{2g}$$

In actual practice, especially in the case of long pipes, the kinetic energy is less than the theoretical work, the difference being due to the energy lost in overcoming friction. Consequently, $\frac{v^2}{2g}$ in practice is less than the total head h. Now, $\frac{v^2}{2g}$ is the effective head, corresponding to the velocity at discharge, and is sometimes spoken of as the velocity head. Therefore the loss of head due to frictional resistance must equal

$$h - \frac{v^2}{2g}$$

For great lengths of pipe the velocity may become very small, showing that nearly all of the head has been lost in overcoming the resistance.

Several conditions must be taken into account to find the actual velocity of water in a pipe, the number of conditions depending on the particular pipe line under consideration. When water from a

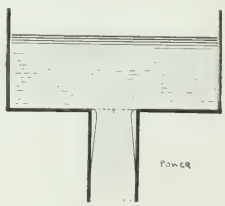


FIG. 2

reservoir, tank or other source of supply enters a pipe there is more or less contraction and resistance of the stream, as shown in Fig. 2, the amount depending upon the manner of connection.

The loss of head due to contraction and resistance of the inner edges of the pipe is known as the loss of entrance, and depends on the manner of connection and the shape of the end of the pipe. The loss of head may be expressed by the formula

$$h_1 = m \frac{v^2}{2g}$$

in which

h_1 = Head, in feet, lost at entrance;

v = Velocity, in feet per second;

m = Coefficient depending on the form of the end of the pipe.

When the pipe projects into the reservoir or tank m equals 0.93; when it is flush with the reservoir, as in Fig. 2, m may be taken as 0.5, and when the inner end of the pipe is provided with a bell-shaped mouth m equals 0.

Loss of head due to friction and cohesion along the interior surface of the pipe must be taken into account, as this is usually large, especially in long pipes. A formula for the head lost in frictional resistance which has been derived from experimental data is as follows:

$$h_2 = f \frac{v^2 l}{2 g d}$$

in which

h_2 = Head lost by friction;

f = Friction factor which depends on the condition of the interior of the pipe;

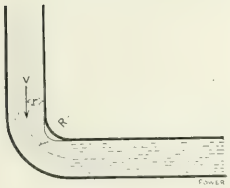


FIG. 3

l = Length of pipe in feet;

v = Velocity of water, in feet per second, flowing in pipe;

g = 32.16;

d = Diameter of pipe in feet.

The value of f ranges from 0.05 to 0.01 for new clean pipes, but for the average conditions in practice f is taken as 0.02, which value may be used in making calculations unless another value is specified.

If a pipe is straight and of uniform size throughout, the loss of head at the entrance and that due to frictional resistance of the interior surface is all that need be considered, but if the pipe varies in diameter, has sharp bends or turns, or contains valves, other losses must be considered.

In practice, variation in diameter of the pipe is usually made by means of a reducer so that the change in section is gradual. This being the case, the loss of head due to this cause is very small, and for most practical purposes may be neglected.

Sharp bends or turns, as in Fig. 3, cause considerable loss of head, especially when several such abrupt changes are made. The loss of head caused by a sharp bend of 90 degrees, as in an elbow, may be found by the following formula:

$$h_3 = c \frac{v^2}{2 g}$$

in which

h_3 = Loss of head in feet;

c = Constant which depends on the ratio $\frac{r}{R}$, of the inside radius of the pipe to the radius of curvature of the bend;

v and g are the same as in previous formulas.

The values for c may be found from Table 1, in which r is the radius of the pipe and R the radius of the bend.

Valves for regulating the flow in pipes may cause considerable loss of head when they are not fully opened. The loss of head may be found by the formula,

$$h_1 = c' \frac{v^2}{2 g}$$

The constant c' for a cock valve, as shown at the left in Fig. 4, may be found from Table 2, in which a is the angle which the opening through the valve makes with the axis of the pipe.

TABLE 1. COEFFICIENT FOR LOSS OF HEAD DUE TO SHARP BENDS

$\frac{r}{R}$	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1.0
c =	0.13	0.14	0.16	0.21	0.29	0.44	0.66	0.98	1.41	1.98

TABLE 2. COEFFICIENT FOR LOSS OF HEAD DUE TO COCK VALVES

a =	0°	10°	20°	30°	40°	50°	55°	60°	65°
c' =	0	0.29	1.6	5.5	17	53	106	206	486

The constant c' for a gate valve, as indicated at the right in Fig. 4, may be found from Table 3, in which $\frac{d_1}{d}$ is the ratio of the distance the gate is lowered below the top of the pipe, to the diameter of the pipe.

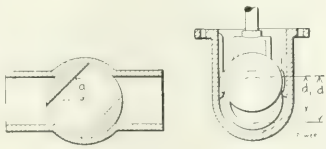


FIG. 4

TABLE 3. COEFFICIENT FOR LOSS OF HEAD DUE TO GATE VALVES

$\frac{d_1}{d}$	0	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{3}{8}$	$\frac{1}{2}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$
c' =	0	0.07	0.26	0.81	2.1	5.5	17	98

VELOCITY OF FLOW

Having determined the losses of head, due to various conditions, the resulting velocity may now be found. Since h loss of head, $h = \frac{v^2}{2g}$ must equal the velocity head, or the head corresponding to the velocity of the issuing stream, the lost head, $h = \frac{v^2}{2g}$ must equal the sum of the various head losses; that is,

$$h = \frac{v^2}{2g} = h_1 + h_2 + h_3 + h_4$$

or

$$h = \frac{v^2}{2g} = m\frac{v^2}{2g} + f\frac{v^2 l}{2gd} + c\frac{v^2}{2g} + c'\frac{v^2}{2g}$$

Dividing this expression by $\frac{v^2}{2g}$,

$$\frac{2gh}{v^2} = 1 = m + f\frac{l}{d} + c + c'$$

from which

$$v = \sqrt{\frac{2gh}{1 + m + f\frac{l}{d} + c + c'}} \qquad (1)$$

which is a general formula that may be used for the velocity of flow. If there are no valves to be taken into account, then c' becomes zero, and if there is more than one valve, then c' represents the sum of the constants for the various valves. In a similar manner, if there are no bends in the pipe c becomes zero, and if there is more than one bend, c represents the sum of the constants for the various bends.

Example: A 6-inch pipe line 500 feet in length delivers water from a reservoir 60 feet above the outlet. The pipe makes two right-angled turns and the gate valve at the reservoir is wide open. If the pipe projects into the reservoir and the radius of the bends is 15 inches, what is the velocity of flow in the pipe?

Solution: Apply the general formula (1) for the velocity of flow, substituting the following values: $g = 32.16$; $h = 60$ feet; $m = 0.93$; f may be taken as 0.02; $l = 500$ feet; $d = \frac{1}{2}$ foot. Since the radius of the bends is 15 inches, then from Table 1

$$\frac{r}{R} = \frac{3}{15} = 0.2$$

and $c = 0.14$ for one bend or 0.28 for two bends; $c' = 0$, since the gate valve

is wide open. Substituting in the formula,

$$v = \sqrt{\frac{2 \times 32.16 \times 60}{1 + 0.03 + 0.02 \times \frac{500}{0.5} + 0.28 + 0}}$$

$$= 13 \text{ feet per second}$$

Quantity of Discharge

The general formula for the velocity of flow in feet per second having been obtained, the discharge, q in cubic feet per second, is readily found from the expression

$$q = av$$

previously given. This becomes

$$q = 0.7854 d^2 \sqrt{\frac{2gh}{1 + m + f\frac{l}{d} + c + c'}}$$

$$6.3 d^2 \sqrt{\frac{h}{1 + m + f\frac{l}{d} + c + c'}} \qquad (2)$$

In order to show the application of the foregoing formulas, a practical problem which recently came up will be solved.

A tank 20 feet in hight and 20 feet in diameter is erected on a tower 30 feet high. Into the center of the bottom of the tank a 6-inch pipe is connected so that the pipe is flush with the bottom of the tank. The pipe runs 30 feet vertically downward, then turns at 90 degrees, running horizontally 300 feet and discharging through a gate valve, as shown in Fig. 5. What is the discharge when the tank is full?

The total head in this case is

$$30 + 20 = 50 \text{ feet}$$

and the total length of the pipe will be about

$$300 + 30 = 330 \text{ feet}$$

In this case there will be loss of head at the entrance to the pipe, loss of head due to friction in the pipe, loss of head due to the 90-degree bend and loss of head due to the gate valve if it is not fully opened. In this case, however, the gate valve has been assumed as wide open. Applying the general formula and substituting for the values of the various factors: $g = 32.16$; $h = 50$ feet; $m = 0.5$, since the end of the pipe is flush with the bottom of the tank; $f = 0.02$; $l = 330$ feet; $d = \frac{6}{12} = \frac{1}{2}$ foot; $c = 0.29$, as found from Table 1 if the 90-degree bend has a radius of 6 inches; as the gate valve is assumed to be wide open, c' becomes zero.

$$= 6.3 \times (\tfrac{1}{2})^2 \sqrt{\frac{50}{1 + 0.5 + 0.02 \times \frac{330}{0.5} + 0.29}}$$

$$= 2.87 \text{ cubic feet per second}$$

Expressed in gallons, the discharge is

$$2.87 \times 7.48 = 21.47$$

or approximately 21½ gallons. This discharge is on the assumption that the gate valve is wide open. If the gate valve were partly closed it would be necessary to know the ratio $\frac{d_1}{d}$, Fig. 4, and then substitute the value for c', as found from Table 3.

Head Required to Produce a Given Delivery

It is sometimes necessary to find the head required to produce a given flow. This being the case, the general formula (2) for the quantity of discharge may be transposed and the value of h found. Squaring both sides of the equation and solving for h, a general formula for the required head is

$$h = 0.0252 (1 + m + f\frac{l}{d} + c + c')\frac{q^2}{d^4} \qquad (3)$$

TABLE 4. SIZES OF STANDARD PIPES

Size, Inches	Diameter Internal	Diameter External	Size, Inches	Diameter Internal	Diameter External	Size, Inches	Diameter Internal	Diameter External
⅛	0.27	0.40	2½	2.47	2.87	9	8.94	9.62
¼	0.36	0.54	3	3.07	3.5	10	10.02	10.75
⅜	0.49	0.67	3½	3.55	4	11	11	11.75
½	0.62	0.84	4	4.03	4.5	12	12	12.75
⅝	0.82	1.05	4½	4.51	5	13	13.25	14
1	1.05	1.31	5	5.04	5.56	14	14.25	15
1¼	1.38	1.66	6	6.06	6.62	15	15.43	16
1½	1.61	1.90	7	7.02	7.62	16	16.4	17
2	2.07	2.37	8	7.98	8.62	17	17.32	18

Diameters of Pipes to Meet Specified Conditions

In practice it is often necessary to find the diameter of the pipe to give a required discharge. A general formula suitable for this purpose may be derived from formula (3), but this would run into some difficult mathematics, and in order to find the diameter it would be necessary to extract the fifth root, which would require a knowledge of logarithms. A simpler method, and one which is just as satisfactory, is to assume a diameter and then substitute this assumed value in either formula (2) for finding the quantity of discharge, or in formula (3) for finding the head. If the first assumption made does not give the quantity of discharge or the head desired, assume a new value for the diameter and repeat the calculation. By this cut-and-try method a diameter may be found which will satisfy the conditions. This diameter will then be taken as the diameter of the pipe.

For example: Let it be required to find the diameter of a pipe to give a discharge of 21½ gallons per second for the conditions in Fig. 5. The discharge in cubic feet is

$$21.5 \div 7.48 = 2.87$$

As a trial value, assume the diameter of the pipe to be 5 inches or 0.4166 foot. Taking a value of $m = 0.5$, $f = 0.02$, $l = 330$ feet, and if the radius of the bend is taken equal to the diameter of the pipe or the ratio of the radius of the pipe to the radius of the bend equals 0.5, then from Table 1 the constant $c = 0.29$ and $c' = 0$. Substituting in formula (3) and solving for the head,

$$h = 0.0252 (1 + 0.5 + 0.02 \times \frac{330}{0.4166} + 0.29 + 0) \frac{(2.87)^2}{(0.4166)^4} = 121.48 \text{ feet}$$

which is too great. Since the head is to be 50 feet, a larger size of pipe must be used. Assuming a 6-inch pipe and recalculating,

$$h = 0.0252 (1 + 0.5 + 0.02 \times \frac{330}{0.5} + 0.29 + 0) \frac{(2.87)^2}{(0.5)^4} = 50 \text{ feet}$$

which is the head required. Therefore, a 6-inch pipe would be used.

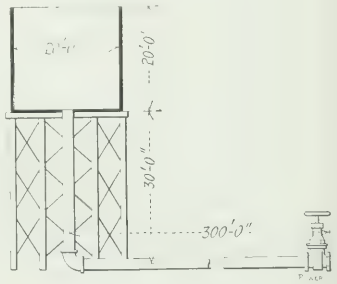


FIG. 5

Comparative Flow of Water in Pipes of Different Sizes

The foregoing example shows that in the particular case in question the 5-inch pipe requires more than twice as much head as the 6-inch pipe in order to give the same quantity of discharge. Of course, the velocity must be much higher in the 5-inch pipe. At the same velocity of flow two pipes discharge as the square of their diameters—that is, in the case of the pipes mentioned the ratio of discharge will be $(5)^2 : (6)^2$, or 25 to 36. The same head will not produce the same velocity in pipes of different diameters or lengths. The chief resistance to the flow of the water in a pipe is due to the friction of the water upon the sides of the pipe. This friction is greater in proportion to the contents of a small pipe than of a large pipe—that is, in a given length of pipe there is more interior surface in proportion to the contents in the

case of the small pipe than in a larger pipe, and consequently the frictional resistance is greater in the small pipe.

The relative flow in pipes of different sizes under similar conditions may be found approximately by the following proportion, which has been derived from a large number of experiments:

$$N : N_1 = \frac{d^5}{\sqrt{d_1 + 3.6}} : \frac{d_1^5}{\sqrt{d_1 + 3.6}}$$

in which N is the number of pipes of diameter d and N_1 is the number of pipes of diameter d_1.

For example, suppose it is necessary to find the number of 2-inch pipes required to replace one 7-inch pipe so that the quantity of discharge under similar conditions in each case will be the same. The actual internal diameter of a standard 2-inch pipe is 2.07 inches and of a 7-inch pipe is 7.02 inches. Substituting in the proportion:

$$1 : N_1 :: \frac{(2.07)^5}{\sqrt{2.07 + 3.6}} : \frac{(7.02)^5}{\sqrt{7.02 + 3.6}}$$

or

$$1 : N_1 = 3.64 : 106.18$$

from which

$$N_1 = \frac{106.18}{3.64} = 29 \text{ pipes}$$

That is, it requires twenty-nine standard 2-inch pipes to equal one standard 7-inch pipe.

Standard pipe diameters vary slightly from the nominal diameters, as is shown by Table 4.

This table will be found convenient, especially where accurate work is required, and it is necessary to use actual diameters instead of nominal diameters.

The foregoing standard formulas have been found to give good results in practice, but exact calculations are impossible in a majority of hydraulic examples. Actual results may vary from 0 to 10 per cent. from the calculated results, but this is as close as can be expected, due to the number of different factors which tend to modify the flow of a liquid.

The De Laval Multi-Stage Turbine

The turbine is supplied with or without the double helical reduction gears which have been a familiar feature of De Laval turbines, and is adapted to various steam conditions.

It is steam sealed, segmental carbon rings being used in addition to the usual labyrinth packing.

The turbine invented by Dr. De Laval and made by the several companies bearing his name is of the simplest type, in which the steam is utilized in a single expansion from the initial to the exhaust or condenser pressure. The jets impinge with high velocity upon a single row of buckets, the rotative speed of which is limited by centrifugal force. Thus reduction gearing is required to adapt the turbine to most uses. The maximum wheel diameter of single-stage turbines is about 30 in. and the horsepower about 700.

It was to be expected that a pioneer company in this field would progress with the advance of turbine engineering and develop a unit of more complex design and adapted to greater capacities and higher efficiencies.

Some time ago POWER described some large multistage units built by the De Laval Co., of Sweden, and the American company, of Trenton, N. J., now announces its ability to furnish units of this design. The type adopted is the multi-pressure stage turbine.

Although this unit is supplied without gearing, normally it is furnished to drive through twin helical gears. This allows the best design of steam end irrespective of the speed of the driven machine, and

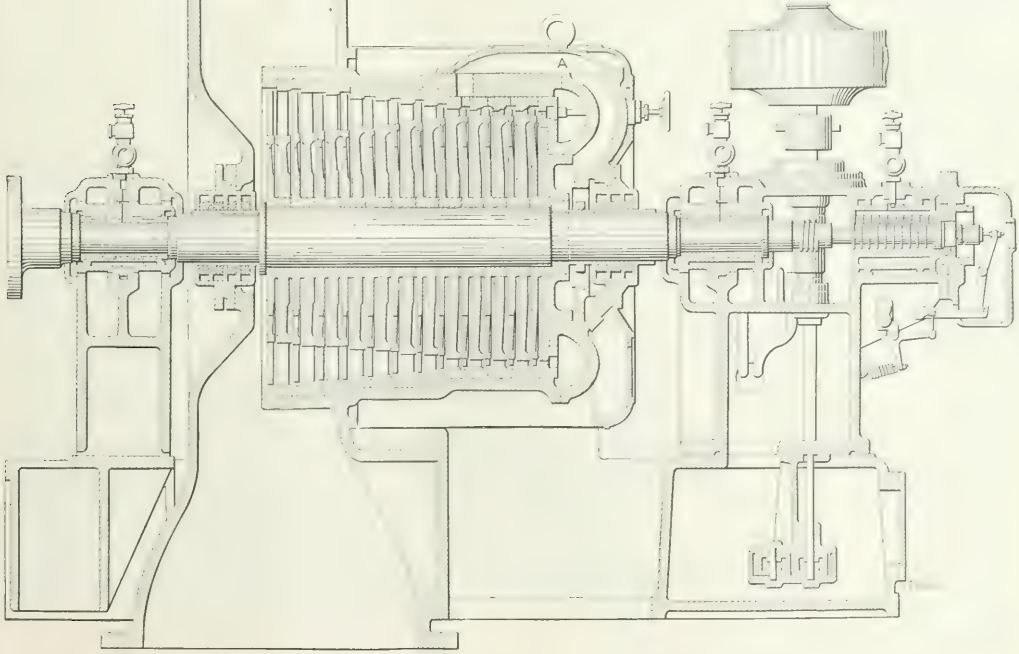


FIG. 1. AXIAL SECTION VIEW, SHOWING ARRANGEMENT OF PARTS

of easily connecting the unit to existing shafting; it also adapts it to direct-current generators or belt and rope drive.

Partial admission to the first chamber is through hand-controlled nozzles which may be adjusted to suit load conditions; full admission to all chambers occurs thereafter, the increase in the area of the steam passages being obtained by lengthening the blades. Fig. 1 is an axial section showing the general arrangement of the turbine. The shaft is heavy and the rated number of revolutions well within the critical speed. The hubs of

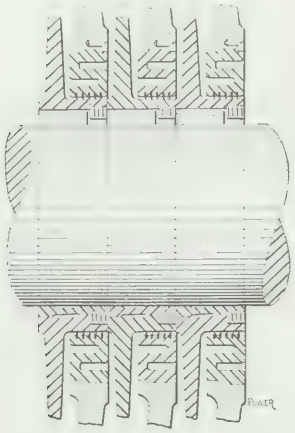


FIG. 2. SHOWING LABYRINTH PACKING

the wheels extend flush with those of adjacent ones, which adds to the stiffness of the shaft. This design permits them to be locked by one nut, and as taper bushings are used in mounting them on the shaft they may be easily removed.

Excepting the nozzles in the first stage, those of each succeeding stage are formed between guide vanes set around the entire periphery of the diaphragms. The diaphragm disks are perforated at the center and fitted with removable labyrinth packing which reduces the leakage from stage to stage between the wheel hubs and the diaphragm. Leakage from the first cell outward to the atmosphere is prevented by labyrinth packing, as shown in Fig. 2, and steam leaking past this packing is led back to an intermediate stage through the passage *A*, Fig. 1.

Following the labyrinth packing is a series of segmental carbon ring packings, each ring being inclosed in a separate compartment, as shown in Fig. 3. The leakage past the first carbon ring is carried back to the exhaust connection or to an intermediate stage of the low-pressure packing. Referring to Fig. 3, provision is made for introducing live steam at reduced pressure between the second and third rings, while on the steam end it may be admitted between the two outermost rings to seal against air leakage into the turbine.

There are three bearings, two being main bearings supporting the revolving parts and the third an adjustable marine-type thrust bearing. The axial thrust,

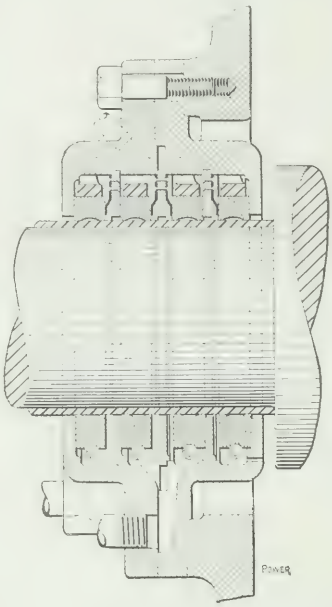


FIG. 3. SHOWING CARBON PACKING

however, is slight as each wheel is surrounded by steam of practically uniform pressure. Each bearing is arranged for water cooling. Lubricating oil is supplied by a circulating pump of the positive-gear type, driven from the lower end of the governor spindle. This pump draws the oil from a reservoir in the box-type bedplate through filter screens, and forces it to an elevated tank from which it gravitates to the sight-feed lubricator on each bearing.

The wheel case is split horizontally in the usual manner, and provision is made for radial expansion by supporting the case in the plane of the center line upon two pedestals rising from the bedplate.

The speed of the turbine is throttle-regulated by a governor of the Jahns type, the valve of which is of the double-seated, balanced-poppet type. The usual safety governor operating an independent valve is also provided.

Fig. 4 shows the turbine driving a 1500-kw. alternator at 1500 r.p.m.

Heating and ventilating engineers welcome the steam turbine for back-pressure service—that is, where the exhaust steam is to be utilized for heating or drying or other commercial purposes—because there is no oil in the exhaust. The absence of pulsations, vibrations and other undesirable qualities also renders this type ideal for all services where power is a byproduct of a steam-using system, such as heating or drying systems.

The trouble with most commercial turbines has been their high steam consumption; consequently where heating is required only during certain months, the great waste of steam during the warm season has about over-balanced the advantage gained by the double utilization of the steam during the heating season. Aside from the unavoidable inefficiency of the high-pressure stages of the reaction type of turbine, due to leakage, this unfavorable opinion has been based in the case of turbines of other types, largely upon experience with turbines built up of large wheels originally intended for condensing service. The loss of power from the friction of a disk running at constant peripheral speed increases as the square of the diameter of the disk and also as the density of the steam; therefore in dense steam as small wheels should be used as is consistent with the flow area necessary to develop the power desired.

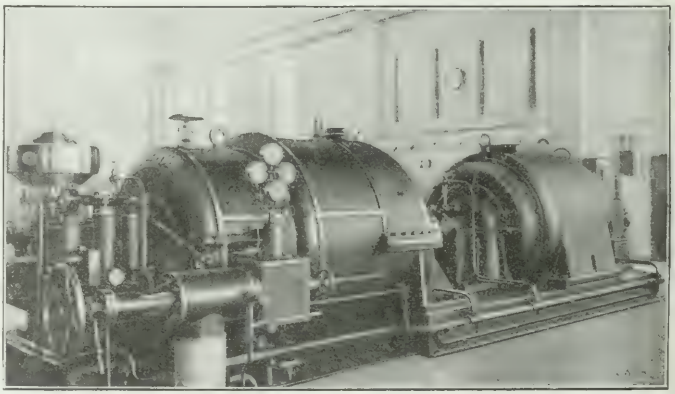


FIG. 4. TURBINE DRIVING 1500-KW. ALTERNATOR

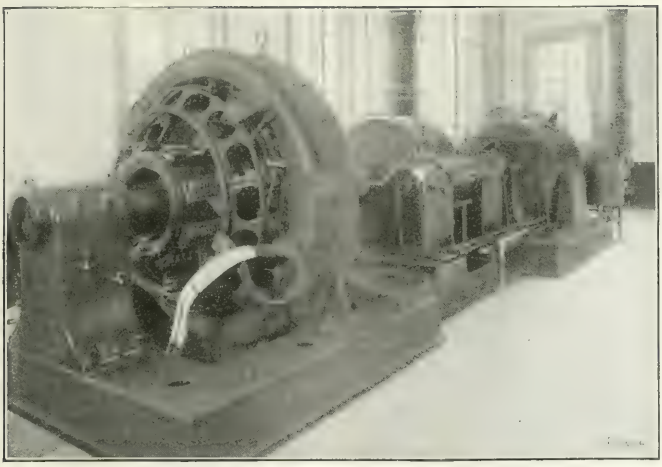


FIG. 5. GEARED TURBINE DRIVING DIRECT-CURRENT GENERATOR

However, with a given steam velocity and the proper ratio of bucket to steam velocity—that is, with buckets moving about one-half as fast as the steam in impulse turbines—small disks lead to high speeds of rotation, which are unsuitable for driving machinery direct-connected. To overcome this difficulty the De Laval turbine is equipped with the helical gearing referred to and described in POWER in the issue of Apr. 11, 1911.

Fig. 5 shows a turbine of this type installed in a cloth-finishing establishment. The plant is old and the power equipment has grown by various additions from time to time. Originally, waterwheels were installed, driving shafting, and later on reciprocating engines were belted to the same shafting. Part of the transmission through the mill is by belt and part by current from generators belt-driven from the shafting. Direct current is used to secure the advantages of variable-speed motors for the printing machines.

The steam turbine was originally put in to help out during the dry season, and the steam required for washing, finishing, bleaching and drying operations was taken at such times through reducing valves. Eventually, it was seen that it would be more economical to allow the turbine to run continuously, supplying the steam required for manufacturing operations, and to shut down the engine, which was operated condensing and the exhaust of which was therefore lost. This conviction was strengthened by the fact that the turbine showed a high thermodynamic efficiency, realizing some 70 per cent. of the total work available from steam between boiler pressure and the back pressure in the exhaust line.

This exceptionally good performance is due both to the small wheels and the high speed used, and also to the close clearances between the shaft and diaphragms made possible by a comparatively small number of wheels and a stiff, rigid shaft. The turbine runs at 3600 r.p.m. and drives a 400-kw. Crocker-Wheeler generator at 600 r.p.m., generating current at 250 volts.

San Antonio Locomotive Explosion*

In its issue of Apr. 9, POWER published an account of the San Antonio locomotive-boiler explosion occurring at 9:30 on the morning of Mar. 18. The report on the accident by Chief Inspector Ensign to the Interstate Commerce Commission, recently received, is so interesting that it is here printed, practically in full.

An incorrect gage and tightening the adjusting screws of the safety valves permitted a pressure beyond endurance of the boiler.

Using 1-in. instead of 1¼-in. bolts for the sling stays reduced the factor of safety to 2.67.

*Abstract of report by John F. Ensign, chief inspector of locomotive boilers, to Interstate Commerce Commission.

BOILER CONSTRUCTION

The locomotive was of the heavy passenger 4-6-0 type, using crude oil for fuel, and was owned and operated by the Galveston, Harrisburg & San Antonio Ry. Co.; it was built in March, 1908, by the American Locomotive Co. at the Brooks Works. The firebox was of three-piece construction, crown-bar type. The working steam pressure was 200 lb. per square inch. The barrel of the boiler was made of ¾-in. steel in three sections or courses, constructed with butt longitudinal joints having diamond-shaped welts. The dome was located on the third course. The wrapper sheet was 5/16-in. steel, the back head sheet and the back flue sheet ½-in. steel, and the firebox-door sheet, crown- and side sheets 3/8-in. steel. The firebox was stayed with rigid bolts ⅞ in. diameter at the ends, reduced to ¾ in. at the center of the bolts; four rows of 1-in. Tate flexible bolts at the top of the firebox and two rows at each end, staggered at the top corners. The crown bolts were of a driving fit with countersunk heads, 1⅛ in. diameter at the bottom end and 1 in. diameter at the top end, extending through the crown bars with nuts on the top. The crown-sheet was supported by 15 crown bars hung from the wrapper sheet by 168 sling stays, 5/16x3 in., and 12 sling stays ½x2¾ in. The flues, numbering 355, were of 2 in. diameter. The boiler was equipped with three 3-in. Crosby safety valves.

SUMMARY OF EVIDENCE

Briefly summarized, the investigation conducted by the railroad commission of Texas brought out the following facts: The locomotive was out of service from Feb. 21 to Mar. 18, 1912, for repairs, when the following boiler work was done: Two hundred flues reset, one back head brace repaired, one front flue-sheet brace and two throat-stays repaired, eight staybolts renewed, safety valves ground in, steam gage tested and hydrostatic test of 250 lb. pressure per square inch applied. Repairs were completed about 5:45 p.m., Mar. 17, and the locomotive fired up, but no steam was raised. It was again fired up about 6:10 a.m., Mar. 18. The safety valves first opened at 7:30 a.m., at which time the steam gage registered 50 lb. pressure. The safety valves were screwed down and again opened at about 8 a.m., when the gage registered 150 lb. pressure. There is no evidence that the safety valves opened at any time subsequent to 8 a.m. The locomotive had a heavy forced-oil fire from 8 to 8:55 a.m., at which time the explosion occurred.

A railroad employee was engaged in setting the safety valves at the time of the explosion, and, although the evidence showed that the gage had been tested, there was no evidence that the siphon pipe leading from the gage to the

boiler had been cleaned between the valve and the boiler, which is the point where it would be most likely to be obstructed; nor does it appear that the valve was open.

The damage to the boiler, as well as the direction in which the various parts

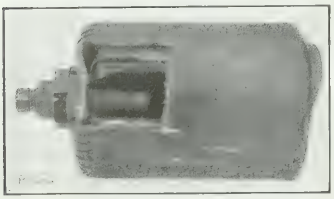


FIG. 1. SAFETY-VALVE CASING, SHOWING ABSENCE OF LOCKNUT AND BENT CONDITION OF SCREW

FIG. 2. SHOWING DISTANCE ADJUSTING SCREW WAS TURNED DOWN TO LOCKING NUT

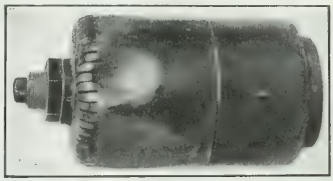


FIG. 3. LOCKING NUT ABSENT AND ADJUSTING SCREW TURNED DOWN AS FAR AS POSSIBLE

of the boiler were thrown, indicate conclusively that the firebox sheets were the first to give way, as the boiler head was blown backward and all other parts of the boiler forward, the flues, flue sheets and smoke arch being simply turned over forward and thrown to the left, while the wrapper sheet and a part of the dome course with the dome attached and other pieces of the shell sheets were driven for long distances forward and to the right.

CONDITION OF SAFETY VALVES

Owing to the damaged condition of the safety valves and the inability to recover the springs and valves, a test thereof could not be made. The casings with the adjusting screws were found, one of which had no locknut. The hexagon-shaped heads on the adjusting screws had the corners twisted off, after which a Stillson wrench had apparently been used in an effort to screw them down further.

One of the adjusting screws was bent and the bottom end was upset or burred by the pressure put on it; the condition of the threads on the adjusting screws indicated that they had been recently screwed down more than $\frac{5}{8}$ in. Reasonable knowledge of the purpose and construction of safety valves should prevent work being done on them which would cause such conditions. Views of the safety-valve casings sectioned to show the condition of the adjusting screws are shown in Figs. 1, 2 and 3.

FAILURE OF CROWN-BAR SLING STAYS

A careful examination of the crown-bar sling stays showed that they were made of wrought iron, while the specifications called for steel. The sling stays were badly stretched and reduced in section at the eyes where they failed, as shown in Figs. 4 and 5, indicating a gradual rise of pressure in the boiler.

Five 1-in. bolts were used to attach the sling stays to the crown bars and to the wrapper sheet, where $1\frac{1}{4}$-in. bolts should have been used; they were specified on the drawings, except on the front crown bar, which called for 1-in. bolts. The crown bars in this boiler were not supported on the sides of the firebox, as was customary in the older type of crown-bar boilers; therefore all the support was from the sling stays.

Five crown-bar sling stays from the locomotive were tested by the United States Bureau of Standards to determine the load the stays would support when 1-in. and $1\frac{1}{4}$-in. bolts were used. The bolts used in making these tests were those used in the boiler at the time of the explosion. Two stays, Nos. 1 and 2, tested with 1-in. bolts, failed with a total load of 26,650 and 21,840 lb. respectively. Three stays, Nos. 3, 4 and 5, tested with $1\frac{1}{4}$-in. bolts, failed with a total load of 30,000, 33,890 and 31,620 lb. respectively.

Using 21,840 lb. as the strength of the sling stays having 1-in. bolts, the stays have a factor of safety of only 2.67, and using the highest test figure of 26,650 lb. the factor of safety was found to be 3.26. Calculation shows that the sling stays fitted with $1\frac{1}{4}$-in. bolts had factors of safety of from 3.67 to 4.15. The tensile strength of the material in the sling stays was shown by test to be 43,200 to 48,300 lb. per square inch and the elongation 18 to 40.5 per cent. in 2-in.. Tests of the sling stays show that the failure was caused by the bolt-holes being drilled too near the ends of the stays. Fig. 6 indicates the manner in which the sling

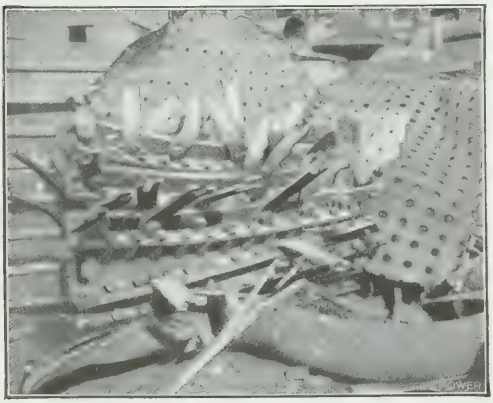


FIG. 4. TOP OF CROWN SHEET, SHOWING HOW SLING STAYS GAVE WAY

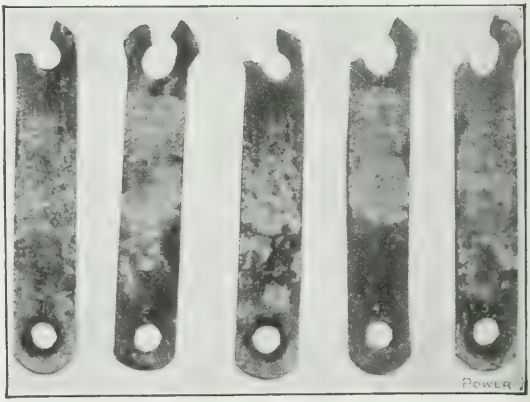


FIG. 5. SHOWING METHOD OF FAILURE AND ELONGATION OF METAL AT EYE OF SLING STAY

stays failed both at the time of the explosion and when under test.

Eighty-six staybolts, nine of which were in the left-side, 63 in the right-side sheet, and 14 in the flue sheet, were found broken at the wrapper sheet and adhering to the firebox sheets. Twenty-six of these staybolts were found to have been partly broken before the explosion. The remaining 60 were in such condition that it cannot be positively stated that they were fractured prior to the accident, but the fact that they broke at the wrapper sheet and did not pull through the firebox sheets indicates a defective condition. Three staybolts taken from this boiler were tested by the Bureau of Standards and the material was found to be of good quality.

Steam Gage Defective

As the steam gage and its connections were destroyed they could not be inspected, but it is probable that the steam gage did not indicate the correct pressure. This could be caused by a defective gage, an obstruction in the siphon pipe, or by a closed or nearly closed valve in the siphon pipe. An inspection of another locomotive of the same class showed that it had two valves in the siphon pipe; when they were open the handle of one formed a right-angle with the pipe and the other was parallel. This arrangement being very confusing and creating a dangerous condition, one valve was ordered removed. It is not known whether such an arrangement of valves existed on the locomotive under discussion.

Inspection Laws Disregarded

The evidence shows that the law and the rules governing the inspection of locomotive boilers were disregarded by the company's inspector and the officials in charge of such work at this point in the matter of making and properly certifying to the reports required by law. A report stating that the safety valves had been set was sworn to on Mar. 16, 1912, by the company's inspector and the roundhouse foreman, who signed it as the officer in charge of such work. The evidence shows conclusively that the safety valves had not been set at that time, and that the explosion occurred while this work was being done. The evidence also shows that the inspector failed to witness the testing of the steam gage and that the injectors had not been tested at the time this report was made out, although he certified under oath that this work had been done.

The flues and firebox sheets show no indication of having been overheated, and the evidence makes it plain that there were three gages of water at the time of the explosion.

Cause of Explosion

The chief inspector and his assistants conclude that this explosion was due to excessive steam pressure caused by a railroad employee tightening the adjusting screw of the safety valves, resulting in an accumulation of steam pressure beyond the endurance of the boiler.

Tests made of the parts of the boiler which evidently failed first demonstrate that the pressure on the boiler at the time of the explosion was greatly in excess of the allowed working pressure. Therefore, the steam gage, either on account of the gage itself being defective or of an obstruction in the siphon pipe between the gage and the boiler, did not correctly indicate the pressure.

The railroad company was at fault in requiring or permitting inspections and reports to be made not in accordance with the law, and in allowing such responsible work as setting safety valves to be performed by an employee of whose experience and judgment, the testimony shows, the management knew practically nothing, and in keeping a boiler in service for which the factor of safety as shown by test was below the recognized standard.

The rules governing the inspection of locomotive boilers, setting of safety valves, testing of gages and similar work are sufficiently comprehensive to insure safety if properly and intelligently complied with.

However, in endeavoring to obviate a recurrence of this accident, necessary action has been taken compelling the use of two steam gages when setting safety valves, one of which must be so connected that it is in full view of the person engaged in setting such valves. Similar action has also been taken requiring the siphon pipe and its connections to the boiler to be cleaned each time the gage is tested.

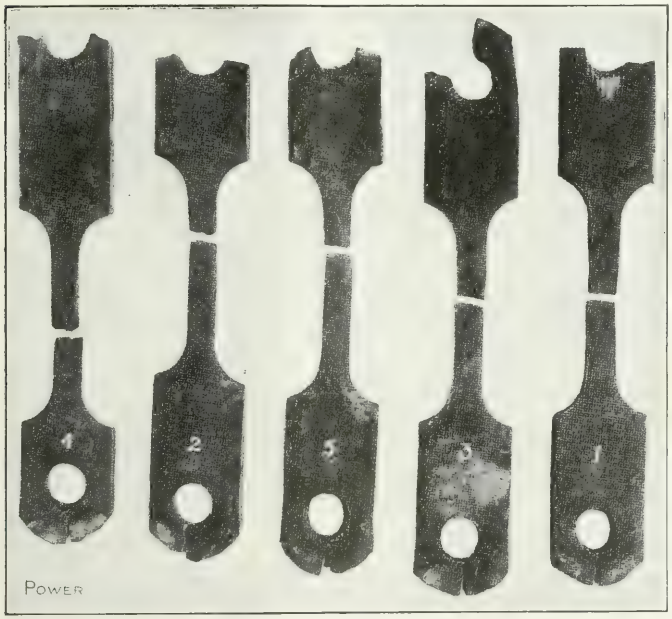


Fig. 6. Results of Tensile Tests on Sling Stays and at Lower End of Tests with 1 and 1¼ inch Bolts

New Mexico's coal production in 1911 was 3,148,158 short tons, with a spot value of $4,525,925, according to a statement by E. W. Parker just made public by the United States Geological Survey. In common with most of the states in the Rocky Mountain region New Mexico produced less coal in 1911 than in 1910, a decrease of 360,163 short tons, or 10.3 per cent. Colfax County, in addition to producing 75 per cent. of the total output of New Mexico, is also the only county in which coking operations are carried on, and in 1911 a total of 767,108 tons of coal mined in that county was made into coke. In 1910 the coal made into coke in Colfax County amounted to 701,204 tons.

The state charter of the Kittanning Water Power Co., a Pittsburg corporation, has been approved by Gov. John K. Tener. The company will give the state entire authority over the construction and operation of its dams and works in Armstrong and Indiana Counties.

Significance of Draft in Boilers

By L. B. Lent

The quantity of gas passing per unit of time is proportional to the pressure drop between two points, the resistance being constant rather than variable.

The above is the title of a bulletin recently published by the U. S. Bureau of Mines and written by Walter T. Ray and Henry Kreisinger. The information it conveys is well worth the serious consideration of anyone interested and will perhaps tend to revise some ideas about this important subject.

Authorities do not seem to agree as to the relation of draft to the amount of combustion or the rate of combustion. Snow says "that for comparison of combustion rates the draft which should be determined is that relating solely to the supply of air to and the overcoming of resistances in the fire. This draft is obviously the difference between the over- and under-grate pressures." This difference between over- and under-grate pressures, Snow calls the effective pressure ("Steam Boiler Practice," page 216).

Kinealy states in his book "Mechanical Draft" that "the number of pounds of coal burned per square foot of grate surface per hour is directly proportional to the square root of the draft." He defines the draft as that measured at the end of the uptake just where it enters the chimney. Evidently the total draft is meant.

According to the Bureau of Mines bulletin, neither of these statements is correct, the rate of combustion being proportional to neither the effective nor the total draft. A clear conception of the meaning of the term "draft" is essential to a proper understanding of what follows. This term is sometimes taken to mean the actual flow of gases, but the proper idea is that it means the difference of pressure which causes the flow. Whether this difference is caused by a chimney (natural draft) or by a fan (induced or forced draft), it is the excess of pressure which pushes the gases through the closed circuit. A flow of gas can never be induced by any "pull" or "suck," as some think. For this reason, the existence of pockets or dead spaces is not the result of any one system more than another, provided the setting is tight.

The movement of gas through the boiler may be compared to that of water through a pipe or to that of electricity through a conductor. The draft producing the flow may be compared to the head of water or to the potential or voltage in the electric circuit. The resistance of the grate, the fuel bed, the gas passages through the furnace, the tubes and other parts determines the amount of air or gas which will flow under the given conditions.

For any given boiler, the resistance of the gas passages from over the fuel bed to the uptake is practically constant; and it is affected in only a slight degree by the condition of the tubes, plates and setting in contact with the gases. The resistance of the fuel bed is apt to be quite variable, depending on the quality of the fuel and the thickness of the bed. Assuming that the latter is the varying resistance and the former the fixed resistance, then this varying resistance may be a greater or less part of the total resistance, according to conditions.

To ascertain the relation of the variable and fixed resistances and of the total resistance, suppose the grate and fuel bed were removed from the boiler. Then this resistance would become zero, the drop in pressure through the grate and fuel bed would be zero and for a given total head the quantity of gas passing would be a maximum. If the grate were replaced without any fuel on it, the slight resistance of the grate would cause a slight pressure drop through it and the quantity of gas passing would, for the same total draft, be slightly less than in the preceding case. If the total draft or pressure difference was 1 in. of water, the drop through the grate might be 0.1 in. of water, the fixed resistance being 0.9 in.

If a thick bed of fuel be placed on the grate, the variable resistance will become very much greater and the quantity of gas passing for the same total head will be very much less.

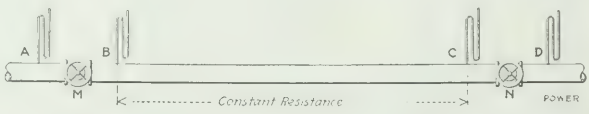
Suppose the grate to be momentarily blanked off so that no gas could pass through it, then the resistance would be a maximum, the pressure above the grate would be the same as that in the uptake and the drop in pressure through the grate would be equal to the total draft. In this limiting case, in which the "effective draft" is greatest, the amount of air flowing is a minimum or zero.

What the writer attempts to show clearly is that a large drop in pressure through the fuel bed (the "effective draft" of some authorities) is simply indicative of a high resistance through the bed and taken alone, is no indication of the amount of gas passing through the bed. Indeed, a large drop in pressure through the bed indicates a small amount of flow if anything.

The flow of gas through all parts of the boiler is caused by a diminution of pressure from one part to another and hence a more or less gradual diminution of pressure from the ashpit to the uptake. This drop in pressure from one part to another varies as some power of the resistance to the flow of gases.

1. If the total resistance to the flow of gases remains constant, the pressure drop through any portion of the path of the gases will have a constant ratio to the total drop from the ashpit to the uptake. For example, if the pressure drop through the fuel bed is 0.5 in. of water when the total drop is 1 in., it will be 1 in. if the total drop be increased to 4 in. of water.

2. If the total pressure drop from the ashpit to the uptake remains constant the pressure drop through any portion of the gas path will vary in the same direction as does the resistance to the flow of gases, although the magnitude of the variations may not be in simple proportion. Suppose the total drop to be 1 in. of water and the drop through the fuel bed is 0.5 in.; now if the total drop be kept the same but the resistance through the fuel bed be doubled by doubling its thickness, the pressure drop through the fuel bed will increase to about 0.65 in. of water; or if for the same total drop, the resistance of the fuel bed be increased by quadrupling its thickness, the drop through the bed will increase to about 0.8 in. of water.



CONSTANT AND VARIABLE RESISTANCE

3. When the resistance through any portion of the gas path remains constant the weight of gas passing through this portion varies as some power of the pressure drop through this portion. Thus, since the resistance of that portion of the gas from over the fuel bed to the uptake is ordinarily very constant, the weight of gases passing through the boiler varies as some power of the pressure drop between these points.

Approximately only, the weight of gases passing through the boiler is directly proportional to the square root of the pressure drop through the boiler proper or

through any other portion of the gas path having a constant resistance.

It should be evident from the foregoing that while it necessarily requires a comparatively large drop in pressure to drive air through a thick bed of fuel, this large drop is no measure of the amount of air flowing, and since the rate of combustion depends on the amount of air supplied per unit of time, the drop in pressure through the fuel bed (the "effective draft") is no measure of the rate of combustion.

As previously pointed out, the better measure of the rate of combustion is the pressure drop between the upper side of the grate and the uptake, or any two other points between which the resistance is constant.

Without carefully considering the matter, the inclination is to think that a large difference in pressure over and under the fuel bed must necessarily induce a correspondingly large flow and hence the effective draft through the fire, when large, must produce a large flow of air and a corresponding high rate of combustion. It is forgotten that the real reason for this large difference of pressure is the existence of a high resistance to the flow of gases and that the total head is the available one, the one which really limits the rate of combustion.

Several charts shown in the bulletin and plotted from the test results could be introduced here, but it is sufficient to say that the results obtained from horizontal tubular, water-tube and locomotive boilers show a very close substantiation of the foregoing statements.

Consider for a moment the straight piece of water pipe arranged as shown in the accompanying illustration with two valves and four pressure gages. The straight length of pipe between *B* and *C* has a constant resistance due to its friction alone; the valves constitute variable resistances, depending on how far they are open. Supposing the valve *M* is opened and *N* is closed, the gage *C* will show a 10-in. pressure and no flow will take place. If the valve *N* is cracked open, a small flow will take place and the pressure *C* will be slightly less than *AB*. To be exact, the difference in pressure between *B* and *C* will be the amount necessary to induce a flow at the resulting velocity against the fixed resistance of the pipe friction. The greater the difference in pressure, the greater will be the velocity and the weight of water passing.

With a pressure of 10 in. of water at *A*, the pressure at *B* will depend on how much the valve *M* is opened. Suppose the valve *N* to be fully open so that the flow is unrestricted. Then, if the valve *M* is cracked open, the pressure at *B* will be perhaps 1 lb., the friction of the partially opened valve *M* absorbing the other 9 in. of pressure. The flow of water through the pipe will be that due to the small difference of head between *B* and *C*. As the valve *M* is gradually opened, the pressure *B* approaches that at *A*, the difference in pressure between *B* and *C* increases and the flow of water increases proportionately.

It is a well known law of hydraulics that if the difference in head and the resistance are known, the velocity can be calculated; and for a given size pipe, the volume is proportional to the velocity. If the resistance between *A* and *B* through the valve *M* were known, the velocity could be calculated. But the resistance of the valve *M* is variable and depends on the amount it is open; whereas the resistance of the section of pipe between *B* and *C* is constant and can be measured very accurately from the drop in pressure between those two points.

In any given case, the amount of water passing through the valve *M* in a given interval of time is exactly equal to that passing any other point in the line in the same interval of time. This is one of the basic laws of hydraulics and is sometimes spoken of as the principle of continuity of flow, the law being that the quantity of water passing any cross-section of the passage, no matter what its shape or velocity at the cross-sectional area, is exactly the same as that which passes every other cross-section. This is another way of saying that the same quantity of water comes out one end of a pipe as goes in the other end in the same time.

Assume that the valve *M* may be replaced by the variable resistance of the fuel bed in the boiler and the section of pipe between *B* and *C* by the fixed resistance between the upper side of the fuel bed and the uptake, and practically the same laws hold. As the resistance at *M* increases (by making the fuel bed thicker) the effective head at *B* decreases, the difference in head between *B* and *C* decreases and a less quantity of gas flows. What should be emphasized is the fact that, although the pressures at *A* and *B* may be known, unless the numerical value of the resistance through the valve *M* is known, the quantity of gas passing cannot be calculated nor indicated.

Since the resistance of the gas path between the upper side of the grate and the uptake is practically constant, the quantity of gas passing is proportional to the difference in pressure between these two points; since the same quantity passes through the grate per unit of time as passes these points, the difference in pressure between these points is proportional to the amount of gas passing through the fuel bed and is hence proportional to the rate of combustion.

As the authors of this bulletin carefully point out, the quantity of gas passing is not directly proportional to the difference in pressures, but to some power of that difference. The important point is that the quantity of gas passing per unit of time is proportional to the pressure drop between two points, between which the resistance is constant, rather than to the pressure drop between two points, the resistance between which is variable.

Those desiring to read the full text of the bulletin from which these facts and ideas are taken may obtain it from the Bureau of Mines, Washington, D. C.

Rule for Horsepower

By F. R. Low

A rule for figuring the horsepower of an engine, especially convenient for use with the slide rule, is

Multiply the square of the diameter by 238, by the piston speed and by the mean effective pressure.

Point off seven decimal places more than there are decimal places in the factors used.

The 238 of the rule is the quotient of 7854 by 33.

$$Hp. = \frac{Area \times piston\ speed \times m.e.p.}{33{,}000}$$

$$Area = diameter^2 \times 0.7854$$

$$Hp. = \frac{diam.^2 \times 0.7854 \times piston\ speed \times m.e.p.}{33{,}000}$$

The 33,000 divides the 0.7854 evenly, the quotient being 0.0000238; so that

$$Hp. = D^2 \times 0.0000238 \times p.s. \times m.e.p.$$

Example—What horsepower is developed by a 12x24-in. engine, running at 130 r.p.m. with a mean effective pressure of 42 lb.?

$$12 \times 12 = 144 = D.$$

$$238 \text{ constant}$$

$$1152$$
$$432$$
$$288$$

$$\frac{24 \times 2 \times 130}{12} = 520 = \text{piston speed}$$

$$685440$$
$$171360$$

$$1782440$$

$$42 = \text{m.e.p.}$$

$$35642880$$
$$71285760$$

$$74.8500480 = \text{hp.}$$

Seven decimal places are pointed off in the final product because there were no decimal places in the other figures. There will be no difficulty about this pointing off. It is self-evident that a 12-in. engine is doing more than 7.48, and not so much as 748 hp., so that one will never stop to count decimal places. A rough index of the capacity of a normal engine is one-half the square of the diameter, in this case 72.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Catechism of Electricity

Substations

1277. *What is a substation?*

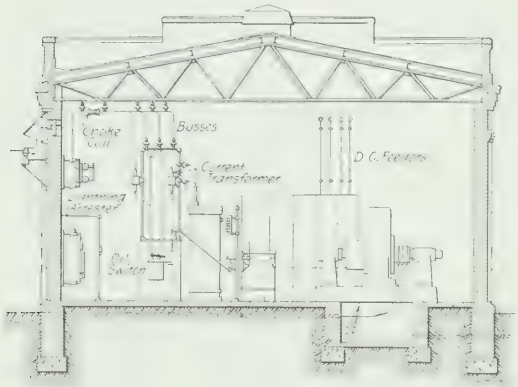
An electrical station in which current is received from one or more large generating stations and in turn supplies a number of feeders which distribute it over the locality where it is used.

1278. *Under what conditions is a substation mostly used?*

In electric-railway work, where the traffic is heavy and the system of distribution widespread; although in some cases it is used for power and lighting systems.

1279. *What advantage is gained by the use of a substation in electric-railway work?*

One large power station can be used for the entire system. This enables the electrical energy to be more economically obtained than when more generating stations are employed.



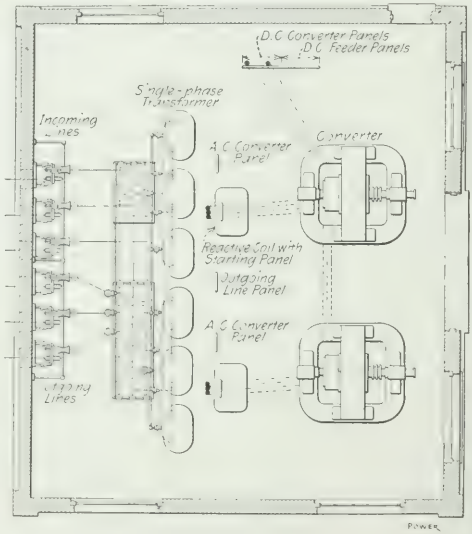


FIG. 421. TYPICAL SUBSTATION ARRANGEMENT WITH FEEDERS ENTERING OVERHEAD

1280. *Is the current handled in a railway substation direct or alternating?*

The currents received at the substation from the generating plant are alternating and of high voltage. These are stepped down by transformers, and by means of rotary converters are changed into direct curent, usually at 550 volts, and supplied to the feeders.

1281. *Why are transformers required in the substation?*

To lower the voltage of the alternating currents supplied from the generating station, so that they are adapted to the rotary converters. This is necessary on account of the fixed ratio which the voltage on the alternating-current side of a rotary converter bears to that on the direct-current side. In a three-phase converter this ratio is 61 per cent.; hence alternating current at approximately 335 volts would be necessary to supply direct current at 550 volts.

1282. *Are motor generators used in substation work?*

Motor generators are seldom used on account of their higher cost as compared with the rotary converters and transformers they would replace.

1283. *Are all substations alike with respect to the method of receiving and distributing the power?*

No. A substation may receive current from the generating station and without any transformations whatever distribute it through switches to other circuits. Another kind of substation may receive high-voltage alternating current from the generating station and, through transformers, reduce its voltage for distribution. A third, as previously described, may receive high-voltage alternating current and distribute low-voltage direct current. Still other substations, common in electric-railway service, carry either storage batteries alone or storage batteries and boosters.

1284. *When are storage-battery substations advantageous for railway work?*

When maintaining a more uniform line voltage and compensating for an extra length of feed wire; relieving the power house of fluctuations of load, keeping the cars moving when the power supply is temporarily interrupted, or in supplying power for the operation of a few cars or lights when the power house is shut down.

1285. *When are boosters used in connection with a storage battery in a substation?*

When current is to be transmitted over a considerable distance to a storage-battery substation for the purposes mentioned in 1284 and the battery must furnish current at the same voltage as developed in the generating plant. The booster makes up for the drop of potential in the line between the generating station and the substation, while the battery is being charged. Also, in railway work, where the load fluctuates within wide limits, a booster is used in connection with the battery. In this case a "differential booster" is used having both series and shunt field windings. Thus the e.m.f. varies automatically with the load and adds to or subtracts from the battery voltage as required.

1286. *What factors govern the location of a substation?*

Practically the same factors that govern the location of a central station, namely: nearness to the center of distribution so

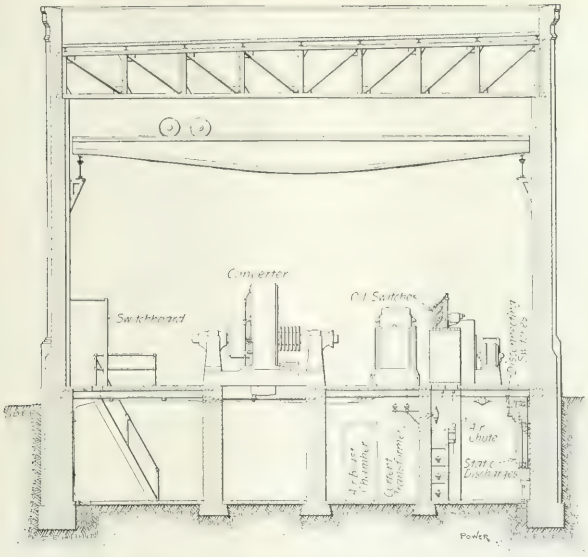


FIG. 422. SECTION THROUGH SUBSTATION WITH UNDERGROUND CABLES

that the drop of potential in the different circuits may be a minimum, also the cost of real estate.

1287. *What kind of a building is best for a substation?*

A detached building, built preferably of brick or other fireproof material.

1288. *What provision should be made for light?*

The substation should be constructed so that plenty of light will enter it, but in a storage-battery room the sun should not shine on any part of the battery. A substation used exclusively for a storage battery is sometimes built without windows, dependence being placed entirely upon incandescent electric lamps for light.

1289. *What provision should be made for ventilation?*

The ventilation of the storage-battery room must be particularly good to prevent the accumulation of fumes; otherwise, it will be almost impossible to enter the room while the battery is being charged, and the hydrogen gas given off while charging, being inflammable, is likely to cause a serious accident if ignited.

The room in which the machines are installed should also have good ventilation because the heat developed in them, even during their normal operation, will considerably increase the temperature. Good ventilation is likewise important where oil-cooled transformers are used, so that the temperature may not become unduly high in the summer-time.

1290. *Is there any reason why the machines should not be located in the battery room?*

The battery should be placed in a room by itself so that the sulphuric-acid fumes given off from the cells will not corrode the metal of the machines.

1291. *What provision should be made for the drainage of a substation?*

Where air-blast transformers are used, the walls of the air-blast chamber should be waterproofed and the substation should be built at such an elevation that water will not stand on the floor of the air-blast chamber. If this latter precaution is not taken, the transformers may be damaged by the warm air from the blower picking up moisture and depositing it in the transformers which are not in service.

When oil-cooled transformers are used, it is well to install a pit of sufficient capacity to drain the oil from several transformers, and to provide drainage piping of ample size from the oil drain-cocks on the transformers to the pit, so that the oil can be drawn off quickly in case of fire or other emergency.

In the battery room the floor, which must never be of wood but of vitrified brick or some other material that is not affected by sulphuric acid, should slope downward toward a drain so that when flooded in washing, it will dry off rapidly.

Where cables come into the station underground, the entering conduits should be sealed and suitable drainage provided so that water cannot leak into the cellar through these openings.

1292. *Give an idea of the general arrangement of substation apparatus.*

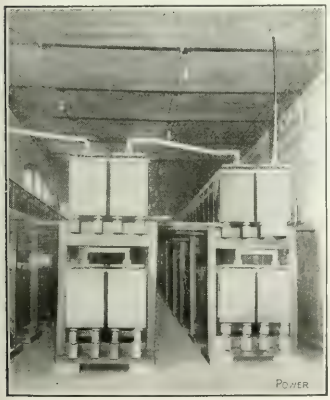


FIG. 423. ARRANGEMENT OF STORAGE BATTERIES WHERE FLOOR SPACE IS LIMITED

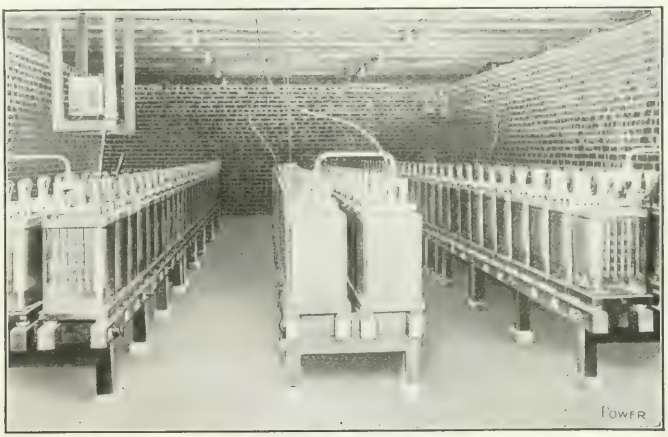


FIG. 424. BATTERIES WHERE FLOOR SPACE IS NOT LIMITED

The arrangement of substation apparatus is largely dependent upon the nature of the switching apparatus. When the cables enter the station overhead, the hand-operated switches are invariably of the top-connected type and the high-voltage busbars are mounted above them. A typical arrangement of this kind is shown in elevation in Fig. 421, which

FIG. 425. PORTABLE RAILWAY SUBSTATION

represents an 11,000-volt installation where oil-insulated self-cooling transformers are used. The high-tension panels are located in front of their respective oil switches and on the operating side of the transformers.

1293. *What arrangement of substation apparatus is customary in case the incoming cables are underground and the switches are motor-operated?*

Fig. 422 shows a section through a substation to meet these conditions. The switches are bottom-connected and the busbars and all high-tension connections are placed below the floor in a suitable compartment. The connections from the high-tension switches to the transformers pass through the partition wall between the high-tension compartment in the basement and the air-blast chamber. The transformers in this case are bottom-connected; that is, both the high-tension and the low-tension leads are brought through their bases. All the main panels, both alternating-current and direct-current, are in one switchboard.

1294. *What is the usual arrangement for the switchboard panels?*

In general, the direct-current switchboard panels are arranged in a group by themselves, the converter panels to the left and the feeder panels to the right, with room for extension at either end. Usually no attempt is made to group the oil switches, either hand-operated or electrically operated, behind the main switchboard, the oil switches being invariably located, in the more recent types of construction, immediately adjacent to their banks of transformers or line entrances, or exits, as the case may be. For all stations using hand-operated switches, this makes it advisable to locate the alternating-current line and converter panels in corresponding positions. With electrically operated switches, there is no definite relation between the location of the panel and its switches. No incoming line panels are used unless the lines are in duplicate, a single incoming line being wired to the substation busbars without oil switches, but with disconnecting switches.

1295. *Upon what considerations does the arrangement of a storage-battery substation depend?*

Principally upon the amount of available floor space and the accessibility of the cells for inspection and handling.

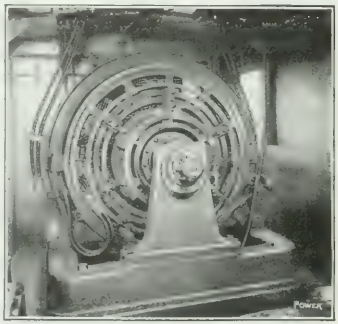


FIG. 426. CONVERTER IN PORTABLE SUBSTATION

1296. *When the floor space is limited, what is the best arrangement of the cells?*

In tiers, one above the other, as shown in Fig. 423.

1297. *Are the cells in Fig. 423 convenient for inspection and handling?*

Inspection of the cells is not difficult in this installation because ample room has been left between the two tiers and between the ceiling and the upper tier. The handling of the cells, however, is not convenient; without a traveling crane it would be almost impossible to move any of these cells with ease and safety.

1298. *Where the floor space is not limited, what is the best arrangement of the cells?*

In rows on supports resting upon the floor as in Fig. 424.

1299. *Is there any objection to placing the cells directly upon the floor?*

It is not advisable to do this because moisture would accumulate under the cells, and this, together with the battery solution, would form a conducting path from one cell to another and cause leakage of current. Hence, it is customary to use insulating supports under the cells.

1300. *What is gained by having the cells rest upon a board over the insulators as in Fig. 424, rather than directly upon the insulators?*

The board prevents any unequal distribution of the weight of the battery from causing the insulators to be strained or broken.

1301. *Is there any objection, where the space is limited, to placing adjacent cells so close to each other that their cases touch?*

Adjacent cells must be kept far enough apart so that there will be no possibility of coming in contact, else the battery solution is likely to creep across, causing leakage of current.

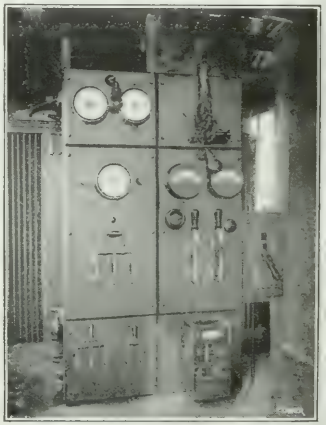


FIG. 427. SWITCHBOARD IN PORTABLE SUBSTATION

1302. *Are provisions ever made in a railroad substation, other than by the overload capacity of the apparatus installed, for taking care of unusually heavy loads at infrequent intervals?*

A portable substation is sometimes used for this purpose.

1303. *What is a portable substation?*

A car such as shown in Fig. 425 arranged for carrying a rotary converter (Fig. 426), transformers, and switchboard (Fig. 427). Such a station for increasing the direct-current supply may be quickly moved to any part of the line, as to fair grounds, amusement parks or summer resorts which are to be served only a few days or weeks.

Locating Cable Grounds

By J. W. Himmelsbach

In underground distributing systems, one or more conductors may become grounded, and circumstances demand that that particular conductor be back in service quickly. Unless the ground produces such violent disturbances that no doubt exists of its location, it is necessary to either cut until the fault is located, which is generally very slow, or else subject the grounded conductor to tests to determine the exact location.

The very satisfactory apparatus described can be easily and cheaply made. The only expensive part is a direct-reading, differential millivoltmeter having the zero in the middle of the scale, which reads 75 millivolts on either side of the zero point. Mount on a piece of well seasoned 5x18x1-in. oak four binding-posts, *A*, *B*, *C*, *D*, and two lamp sockets, *L*, *L*, as shown; *M* and *N* are two small wire brads driven in the board, leaving only ⅛ in. projecting.

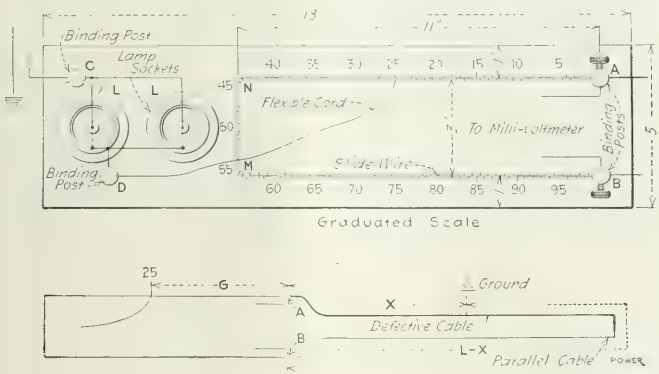
From *A* to *N*, *N* to *M* and *M* to *B*, paste strips of paper 1 in. wide upon which a scale has been drawn, with divisions every ⅛ in., which will give 200 divisions. Mark every second division from 0 to 100, starting at *A*. Then stretch a piece of No. 26 or 28 B. & S. gage, german-silver wire from *A* around *M* and *N* to *B*. This wire must be stretched tightly so that reading the scale will give correct proportional lengths of wire.

The lamp sockets are to be wired in parallel. Connect permanently to *D* a piece of flexible wire (lamp cord will do) to the end of which is soldered a knife-edge contact. This wire must reach from post *D* to post *A*. Binding posts *A* and *B* must have two connectors, as two sets of leads are fastened to them; this completes the testing set.

To prepare for the test, connect to the binding posts *A* and *B* respectively, one lead to the station end of the grounded conductor and one lead to a conductor parallel to the grounded conductor and having the same destination. The ends of these two conductors, away from the testing set, must be joined together. Connect the millivoltmeter to the posts *A* and *B*.

If a 125-volt direct-current circuit is convenient, connect one side to post *C* and ground the other, and place two 16-cp. lamps in the sockets. If no direct-current circuit is available, five or six battery cells connected in series can be used. Connect one terminal to *C* and ground the other; short-circuit the lamp sockets with a plug fuse.

To locate the grounded point, run the knife-edge contact connected to *D* along the graduated wire until the millivoltmeter reads zero. Suppose the reading



Testing Outfit

on the wire is 25 divisions from *A*. Referring to the lower diagram, if the total length of the cable loop is *L*, and the distance from the station to the ground is *X*, then the following proportion holds good:

$$25 : X = 75 : L - X$$

solving for *X*,

$$75\ X = 25\ L - 25\ X$$

$$100\ X = 25\ L$$

$$X = 0.25\ L$$

and if the length of the cable is known, the distance *X* can readily be determined.

Calling the distance from *A* to the point on the slide wire which gives zero deflection on the millivoltmeter *G*, and the distance from *B* around to this point *H*, also the total loop length of the conductor, and the distance from the station to the ground, *L* and *X*, respectively, as before, then:

$$G : X = H : L - X$$

$$G\ L - G\ X = H\ X \qquad (1)$$

but *G* plus *H* equals 100; therefore,

$$H = 100 - G \qquad (2)$$

substituting (2) in (1),

$$G\ L \quad G\ X = 100\ X - G\ X$$

$$100\ X = G\ L$$

$$X = \frac{G \times L}{100}$$

which is the formula to be used when locating grounds with this apparatus.

If the ground is due to water—which will mean that it is not confined to one point—this method is not very satisfactory. If two or three conductors in the faulty cable are grounded, thus making it impossible to get a cable clear from ground for a return, it will, in all probability, be unnecessary to make the location test as a double ground is equivalent to a short-circuit, and short-circuits are usually very apparent.

LETTERS

Commutator Lubrication

I have read with interest Mr. Barrick's letter in the Apr. 30 issue on "Commutator Lubrication." I have had charge of direct current machines for years and do not use any oil or commutator compound whatever, as such things, in my experience, have led to trouble, causing dirt to collect on the comutator and bushes. If Mr. Barrick's commutators are turned off properly, the brushes set correctly and all the connections kept clean, he will have no trouble with sparking provided the machines are properly designed and the load kept within reasonable limits. The use of sandpaper should be discouraged as it soon causes the commutator to be out of true, and also leads to high mica.

One machine in my charge was turned off last in May, 1910, and after carrying 10 per cent. overload during half that time, it has not been turned since.

George Drewry.

Brantford, Ont.

Mr. Barrick's letter recalls to me the method used in a power plant where I was recently employed. A piece of rod packing was kept handy and applied to the surface of the commutators several times a day. This method not only lubricated the commutator but also cleaned them. Commutators treated in this way will keep very smooth, neither sparking nor showing any wear. My chief objection to using oil on a commutator is that it collects on the brushes and makes a sticky base to collect all sorts of dirt.

Frederick Hansa.

New York City.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Trebert Gasoline Engine

One of the most interesting exhibits at the recent aëroplane show in New York was the Trebert engine, a six-cylinder four-stroke-cycle machine in which the cylinders rotate about a stationary shaft. However, unlike the few other engines built on this principle, such as the "Gnome," the cylinders are placed around the shaft with their axes parallel instead of radial to it.

As may be seen from the illustrations the cylinders, which are cast separately, are held in position at the rear by an aluminum crank case and at the front by a ring containing the individual cylinder ports. No valves are used for exhaust or intake, these events being controlled by a stationary disk chamber surrounded by a rotating ring which uncovers the ports at the proper time. The arrangement is as follows:

Attached to the axial shaft is a stationary disk-shaped gas and exhaust chamber divided into two separate compartments with air spaces between, although the outer cylindrical surface is continuous. This also constitutes part of the front bearing for the rotating parts. A pipe leads from the carburetor to the intake compartment, and the exhaust compartment is connected to a muffler, when desired. Around this gas and exhaust chamber fits a revolvable ring carrying the individual cylinder port chambers, each of which is fitted with a packing sleeve bearing lightly against the cylindrical face of the stationary chamber and held in place by springs which counteract any centrifugal force. Holes are bored in the heads of these sleeves to permit an equalization of pressure and thus avoid jamming the springs during compression. In addition, compression plates are fitted between the stationary and the revolving parts to prevent leakage of the gas.

In the cylindrical face of the stationary disk are two elliptical ports, one from the intake chamber and the other lead-

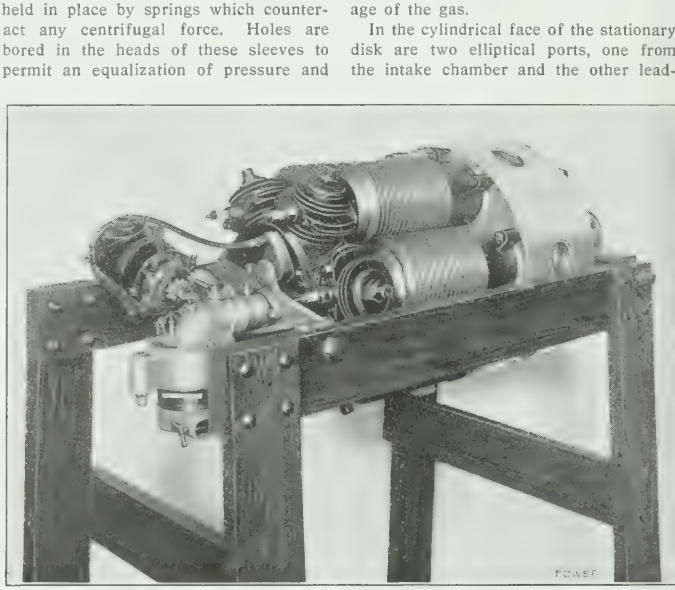


FIG. 1. VIEW OF ENGINE FROM FRONT

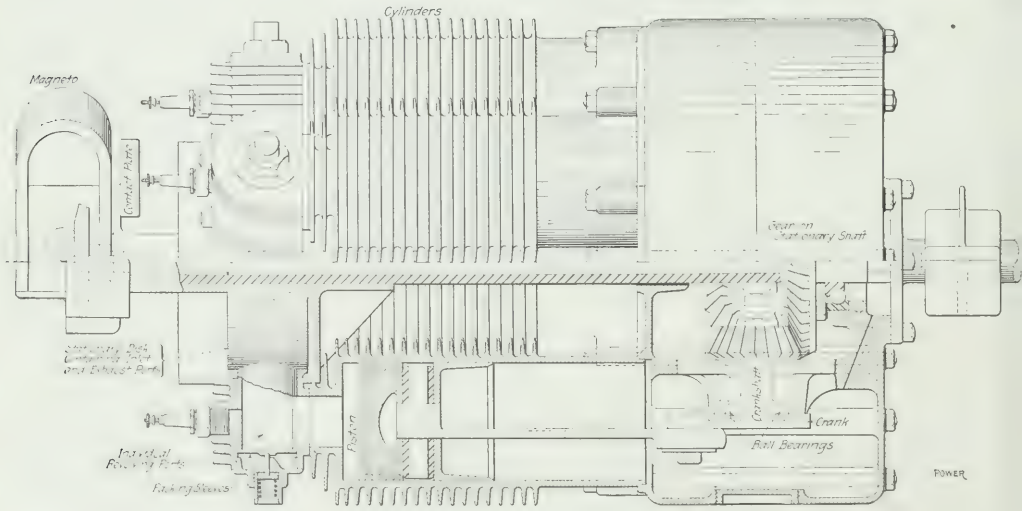


FIG. 2. ELEVATION AND HALF-SECTION OF TREBERT ENGINE

ing to the exhaust pipe, spaced the required angle apart so that the cylinder is always ready to receive gas or to exhaust when its sleeve slides over the proper port. The fresh mixture and burnt gases cannot mingle.

The ignition is extremely simple. The magneto, which is placed at the front of the engine, is driven through a shaft and bevel gear at three times the engine speed. A spark plug is attached to each cylinder-port chamber and in the course of one revolution each passes over the contact plate connected with the magneto. Thus a spark occurs in each cylinder every revolution, and it may be advanced or retarded by a lever which shifts the position of the contact plate. Thus the engine is practically its own timer and distributor.

In the crank case are six crankshafts spaced radially 60 deg. apart—one for each cylinder, They run in ball bearings supported in ribs integral with the crank case, and their inner ends carry bevel gears which mesh with a large bevel gear on the stationary shaft. The outer ends carry cranks which are driven through connecting-rods by the pistons. Thus the whole motor, except the gas and exhaust chamber, and the carburetor and magneto, revolves about the axial shaft which is secured to the front suspension member. The driving shaft projects from the rear of the crank case.

The lubrication also is very simple, three pipes with adjustable sight-feeds sufficing for the whole engine. The cylinders and pistons are lubricated through the gas intake, the oil being introduced into the intake pipe after the gas has left the carburetor. The crankshafts, driving gears and bearings are oiled by two lines running through the center of the axial shaft and emerging just in front of the large gear. From this point the oil is distributed by centrifugal force.

The engine shown in the illustrations is rated at 60 hp. when running at 1000 r.p.m. The cylinders are 3¾-in. bore by 4-in. stroke and the whole engine occupies a space of 32x16x16 in. The weight complete is about 250 lb. The rotating parts themselves provide the necessary flywheel effect, dispensing with the use of a flywheel.

There being six cylinders, each is required to develop only 10 hp. and a complete cycle occurs every revolution (as in a two-stroke-cycle engine); hence there are 6000 power strokes per minute.

While the circulation of air produced by the rotating parts is sufficient to keep the cylinders from becoming overheated with this size of engine, in the larger sizes it has been found advisable to water-cool the cylinders.

CORRESPONDENCE

Backfiring Overcome

As a gas-engine repairman it fell to my lot to work on a small engine installed in a printing plant; it was giving a great deal of trouble by backfiring. The engine was of the four-stroke-cycle, two-cylinder opposed type and was to run on illuminating gas from the city mains. The inlet valves were automatic (operated by the suction of the piston) and both cylinders drew gas from the same mixing valve.

The ignition equipment comprised a small dynamo and a set of batteries for starting, both of which furnished current to a single induction coil. Both primary terminals were led to binding posts, one on the case and the other on the timing device, and each secondary terminal was connected to a spark plug.

The timing device consisted simply of contact pieces *C* (Fig. 1) mounted, one on each exhaust-valve liftrod, which were forced by springs against other stationary contacts *D* mounted on but insulated from the engine frame. One side of the exhaust cam was flattened to allow the roller follower (not shown) to drop and thus make the contact at the proper time. The stationary contacts were insulated from the engine frame, but not from each other.

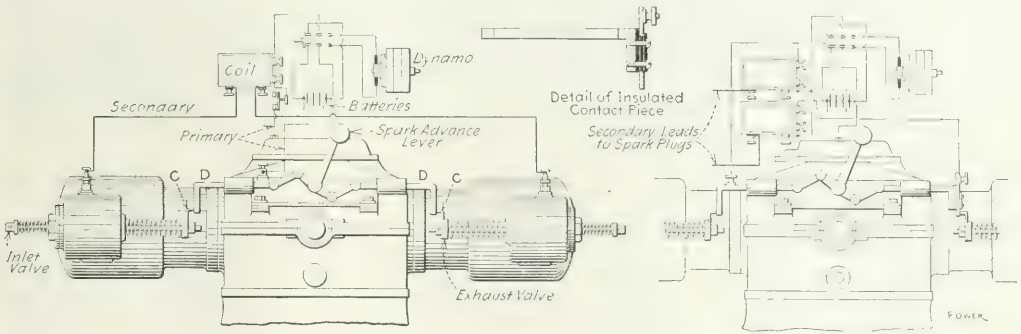
This arrangement caused a spark to occur in both cylinders at the same time. As both pistons travel toward the inner center (away from the cylinder head) at the same time, one on the suction and the other on the power stroke, it is plain that the contact must be broken before the pistons are very far past this center; otherwise the incoming gas of the cylinder which is on its suction stroke will be ignited and cause backfiring.

In this case, the uneven quality of the gas and the variable pressure made a long contact necessary in order to properly ignite the charge, and advancing the spark to the running point would not give an early enough break to eliminate the trouble.

The difficulty was finally remedied by removing one of the stationary contact pieces *C* and replacing it with one which was insulated from both the engine frame and the other contact piece. Another spark coil was added (see Fig. 2), giving one coil for each cylinder, and the trouble so far as backfiring was concerned was eliminated.

J. Arthur Fish.

Kidders, N. Y.



Original Ignition System and that After Altering

The new artificial gas plant installed in East Liverpool, Ohio, is attracting much attention because of the work being done. The builders claimed that from one ton of coal they could produce 40,000 cu.ft. of gas, and the tests so far have shown that they are getting from 55,000 to 70,000 ft. The plant was built to run from 10,000,000 to 12,000,000 cu.ft. a month, but it is expected that the machinery will be able to produce a far greater amount.

For the year 1910, reports the Department of Mines of Western Australia, there were 58 gas engines in use in mines developing 607 hp., while 2933 hp. was developed by 420 oil engines.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Precooling Plant of Southern Pacific

By LeRoy W. Allison

The Southern Pacific Ry. Co. has erected a combined ice-manufacturing and precooling plant at Colton, Calif., to assist primarily in the transportation of perishable fruits, vegetables, etc., from the agricultural belt of southern California. It is one of the largest of such plants, having a capacity of 40 loaded cars, and is operated by the Pacific Fruit Express Co., a subsidiary organization.

The plant has been in active service since the summer of 1909 and embodies the direct-expansion system of refrigeration and a precooling process known as the intermittent vacuum system, offering distinctive and interesting features. The entire plant was designed by A. Faget, of San Francisco; the patents on the precooling process are controlled by L. H. Roy, Chicago, Ill.

General Plan

The entire plant, Fig. 1, excepting the car shed, is built of reinforced concrete. The building at the extreme right of the illustration is the power plant and comprises two 225-ton York refrigerating machines of the double-acting type with ammonia compressors 24x40 in., driven by a tandem-compound Corliss engine 24 and 46 by 36-in. stroke. Steam is supplied by three 250-hp. Stirling boilers, set two in a battery and one single. The usual power-plant auxiliaries, boiler-feed pump, oil-feed pump, circulating pump, fire pump, etc., are installed.

The condensing apparatus both for the steam and ammonia systems are installed in the overhead open portion of the power plant, as may be noticed in Fig. 1. The former installation, on the second floor, is composed of Wheeler condensers. The ammonia system, on the top floor, consists of four sets of ammonia condensers 20 ft. long and 24 pipes high, having 48 coils of 2-in. galvanized pipe. Water for this system, as well as for ice manufacture, is obtained from neighboring artesian wells and irrigation ditches connected to a concrete reservoir at the rear of the power plant. This reservoir is at the surface of the ground and is approximately 8 and 20 by 7 ft. deep.

Electric energy for operation is purchased from a local central station; it is delivered at 11,000 volts and reduced at the company's individual transformer station, adjacent to the power plant, to 220 volts for motor and kindred service.

The main building, centrally located between the two train sheds and icing docks, is 111 ft. 2 in. wide by 276 ft. 8 in. long, and contains the ice-manufacturing and storage plants. The freezing tanks have a capacity of 250 tons daily in blocks of 300 lb. each; the plant is fully equipped with modern ice-making auxiliary equipment and measuring apparatus. Beneath the ice plant a day storage chamber with capacity of 300 tons every 24 hr. is built, while two adjacent winter storage rooms, with total capacity of 17,500 tons, are similarly constructed. The insulation in the building consists of lith board and cork, supplied and installed by the Union Fiber Co., of Winona, Minn. In the storage rooms, this waterproof lith board is 3 in. thick and is bedded in a thick coating of cement; on the outside it is faced with corkboard and waterproof cement.

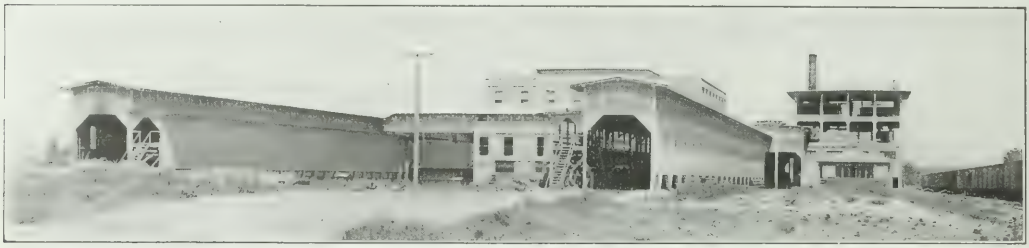


Fig. 1. The S. F. R. Precooling Plant, at Colton, Calif.

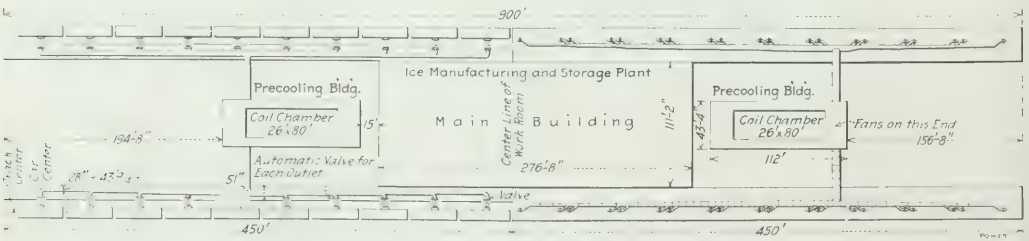


Fig. 2. General Layout of Precooling and Ice-storage Plant

Precooler Coil Chambers

As may be noticed in Fig. 2, two precooling plants are located at either end of the ice-manufacturing plant. They are each 43 ft. 4 in. wide by 121 ft. long and identical in construction, so only one need be considered. The main portion, as seen in the forepart of Fig. 1, is

two stories high, the central portion, directly over the coil chamber, having a half-third story or ventilating deck. An interior view of this section of the building is shown in Fig. 3. The coil chamber is 26x80 ft., and comprises upper and lower sections. The walls are constructed of hollow terra-cotta tile, a double row each 4 in. thick, with two layers of 2-in. lith board insulation between. On the outside, 4-in. corkboard with a pitch asphaltum covering is laid. The ceiling is of the same type of construction, with corkboard on the exterior, while on the floor the insulation is laid on 5 in. of concrete and covered with 2 in. of finished cement concrete. The upper and lower chambers are identical and are used for exhaust from and inlet to the car, respectively.

The precooler chambers contain about 82,500 ft. of 2-in. direct-expansion piping, running coincident with the width of the room. The piping is set in tiers 9 ft. high, with 12 coils to each stand, as shown in Fig. 4.

Two Buffalo Forge fans, with wheels 85 in. in diameter by 27 in. wide, are installed in each precooler house and are used as exhausters. The capacity of each pair is approximately 72,000 cu.ft. of air per minute, under a pressure of 3 oz. and operating at a speed of 380 r.p.m. The fans are placed in wood housing, as shown in Fig. 5, and are driven by Westinghouse motors. These fans are connected to a main 78-in. overhead exhaust duct by 58-in. No. 18 galvanized iron verticals, as indicated in Fig. 6; these pipes are similarly covered with a wood housing, Fig. 5.

The main 78-in. exhaust pipe is made of No. 18 galvanized iron; at the icing dock, where it branches into two longitudinal pipes parallel with the tracks on either side of the building, the size is reduced to 64 in. and uniformly tapers to 24 in. at the end connections. This will be noted in the right half of the plan, Fig. 2, which indicates the exhaust line, and in the cross-section, Fig. 6. The down pipes to the two bunker openings in the refrigerator car are 20 in. in diameter and of similar material, heavily insulated. For a distance of 8 ft. the ends are made of flexible canvas, strongly reinforced with iron rings, to afford adjustment to the varying position of the car. To fit the bunker openings, a wood frame with canvas and tubing on the outer edges is attached to the end of the canvas pipe; when placed in position, this is inflated by means of compressed air to render a tight connection.

The inlet or cold-blast pipe, of No. 18 galvanized iron, leading from the lower coil chamber is 68 in. in diameter. At the icing dock it is reduced to 51 in. and tapers to 28 in. at the end of the main. This is shown at the left half of the plan, Fig. 2, which indicates the inlet lines. At each respective opening, the line is fitted with a large rectangular terminal of a size to suit the side-door opening of the refrigerator car. This ter-

FIG. 3. VENTILATING DECK OF PRECOOLING PLANT

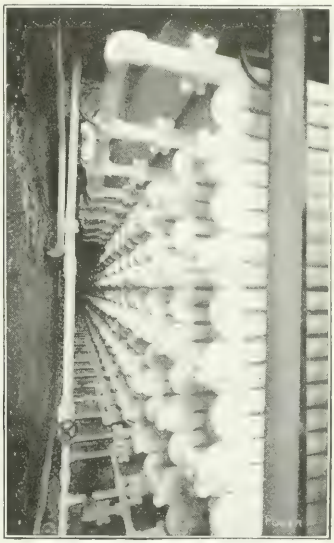


FIG. 4. DIRECT-EXPANSION PIPING IN PRECOOLER CHAMBER

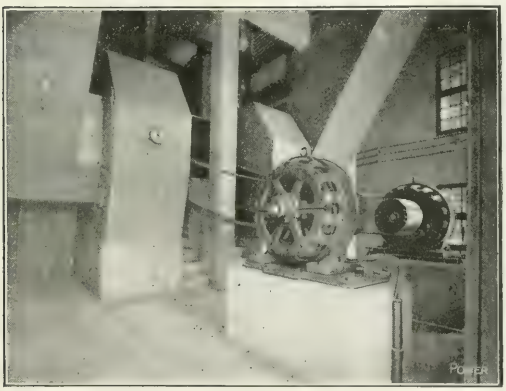


FIG. 5. MOTOR-DRIVEN EXHAUSTERS IN WOOD CASING

FIG. 7. BUTTERFLY VALVES CONTROLLING FLOW OF AIR

minal, or blast door, is of wood framing with an opening about 12 in. long at the top of the interior side, with respect to the car, the opening having curved sheets of galvanized iron to act as deflectors for the strong blast of air which would otherwise enter the car and chill its contents. The edges of the door are made of heavy canvas and interior tubing, to be inflated and allow of an air-tight connection with the car, as in the case of the bunker openings.

Operation

At the end of the precooler coil chambers cast-iron butterfly valves, 48 in. in diameter, are placed as shown in Fig. 7; they operate automatically and control the flow of air through the ducts and cars. The complete details are shown in Fig. 8.

The outlet duct is fitted with automatic valves at each respective opening as indicated in Fig. 2, which work in unison with the butterfly sections in the precooler house. This automatic operation is known as the intermittent process and is the invention of A. R. Sprague; it is from this feature that the system takes its name.

The intermittent device closes the inlet to the car and allows the fans to exhaust all the warm air and gases coming through the butterfly valves from the commodities being precooled. As soon as the butterfly valves close, the inlet valve opens and forces the cool, dry air through the ducts and into the cars. This operation is repeated automatically about once every minute during the first hour of precooling. During this time about 2½ in. pressure shown by water gage to approximately 2½ in. vacuum is obtained. Through the remaining period of the process the exhaust enters the precooler coil chambers, instead of being discharged into the open. Here it is circulated over the coils, deposits its moisture and is cooled, thus allowing the later cold blasts to the cars to be thoroughly dry. Through this time the vacuum is produced at intervals of from 5 to 15 min., depending upon the temperature conditions within the car.

The cold blast ranges from 2 to 3 deg. below zero to about 15 deg. above. The walls of the car are cooled to a temperature of approximately 25 deg., permitting longer preservation of the initial icing and allowing the car to travel a considerable distance before re-icing is necessary. Four hours are required to reduce the temperature of a carload of citrus fruit from an average of about 78 deg. to an average of about 40 deg., while a car of deciduous fruit or vegetables demands about 3 hr. This time could be reduced if fruit shippers would space their loads so as to permit of more free circulation of air. All temperatures are taken in the center of the fruit and the center of the packages.

Many experiments have been made to determine the exact conditions with and without the operation of the intermittent vacuum device. When it is not used and a low temperature is retained on the inlet to the car, the commodities being precooled are liable to freeze. The device permits of a much more equal distribution of air throughout the car than could possibly otherwise be obtained, even though baffles were used.

An icing dock is constructed in the train shed at a height closely approximating the level of the top of a refrigerator car and allows of ready access for filling the car bunkers with ice after the precooling has been completed. The platform is equipped with an endless-chain conveyor for handling the ice and six unloading points thereto are provided leading from the storage chambers in the main building.

The company has expended about $800,000 in developing the Colton plant, and the system has proven so successful that it has erected a similar plant, of slightly less capacity, at Roseville, Calif., to handle the deciduous products from this section of the state.

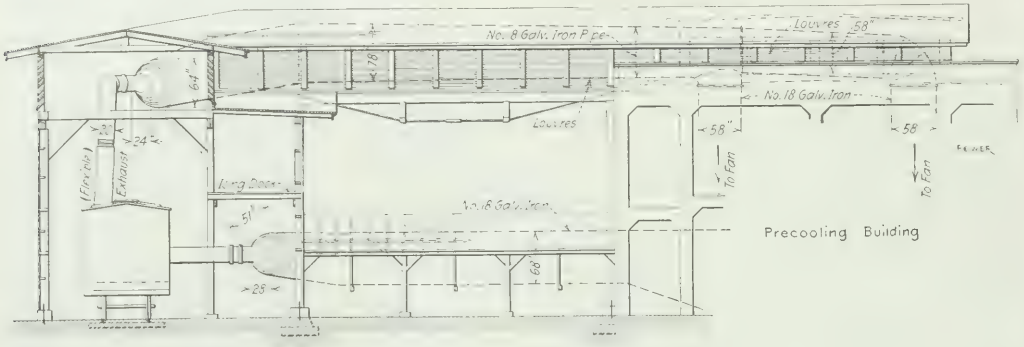


Fig. 6. Vertical Section through Precooling Building

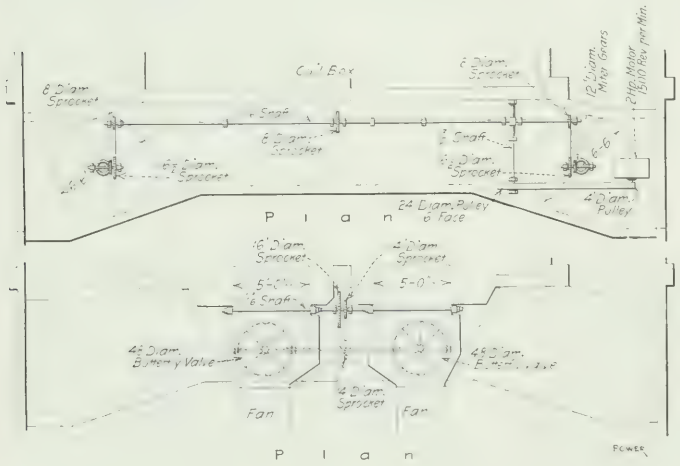


Fig. 8. Mechanism Operating Butterfly Valves

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Turbine or Engine

What is an engine and what is a turbine?

There are those who will respond that all turbines are engines, but all engines are not turbines.

All right, then. When does an engine cease to be a turbine? What is the difference between a turbine and a rotary engine; not in the general but in the particular sense in which the word engine is used?

In the engine, used in this sense, the steam or other working fluid is admitted to a confined space. The molecules of which it is composed fly about in this space and by their bombardment of the containing surfaces produce pressure. Some of the surface, as the piston of a reciprocating engine, moves under the pressure and the work produced is the product of the change in volume and the average pressure during the change.

If steam is permitted to flow without obstruction from a region of higher to one of lower pressure, the energy developed will be applied to getting up velocity in the moving steam and will be present in the stream or jet as kinetic energy. To get the energy out of it the steam must be brought to rest.

A turbine, as we understand it, is a device for doing this. Either by reaction upon the nozzle in which it expands or by impact upon and change of direction by contact with moving surfaces, the fluid mass is brought more or less completely to rest and its energy of motion is appropriated by the device constructed for that purpose; that is, the turbine.

In the engine the pressure of the operating fluid acts directly upon the moving surface, and expansion is controlled by the yielding of that surface under pressure. Kinetic energy comes into consideration only when the analysis goes into the constitution of the steam. The only velocity involved is molecular; the fluid mass simply undergoes change of volume. It is analogous to a weight driving a clock, a restrained, controlled lowering of the weight with a direct conversion of its potential energy into work, or to a hydraulic press pushing a hub on a shaft with a pressure directly applied and moving only as fast and as far as the load moves.

In the turbine the steam acts not by molecular impact but by mass impact; not by static pressure but by momentum and inertia. The pressure acts first upon the working fluid itself and gets up velocity, momentum in it, and then that momentum is absorbed by the turbine. It is analogous to a pile driver, the weight of which gathers momentum in its fall and is brought to rest by impact with the pile upon which the work is to be done.

He who writes definitions hunts trouble, and we do not presume to draw lines where perhaps boundaries should be shaded, but the above seems to us to state the real distinction between the pressure engine, rotary or otherwise, and the turbine.

There has been some discussion in engineering circles as to which class belongs the Spiro motor, described in our issue of Feb. 6. Perhaps it is in the shady borderland between the two. We should be glad to have expressions of opinion from our correspondents.

The San Antonio Report

Some two months ago we published an account of the San Antonio locomotive boiler explosion which resulted in the death of twenty-six and the injury of thirty-two people. In this issue appears an abstract of a noteworthy report on this terrible disaster made by the inspector of locomotive boilers and two assistants to the Interstate Commerce Commission. The report is unusually complete and thorough and is unique among boiler-accident "post-mortems" in that it does not saddle the blame on the killed but puts it where it rightly belongs.

As the report states, the sling stays attaching the crown bars to the wrapper sheet were of wrought iron where the specifications called for steel, and were

attached with one-inch bolts where one-quarter inch larger should have been used. The crown bars, not being supported on the sides of the firebox as in the older type of crown-bar boilers, all the strain was on the sling stays, making it all the more important that the larger bolt should have been used.

Subsequent tests by the United States Bureau of Standards showed that the stays with the one-inch bolts had a factor of safety as low as 2.67, considerably below the recognized standard. With the larger bolt the factor of safety would have ranged from 3.67 to 4.15.

The evidence developed that turning down the adjusting screws of the safety valves and a defective gage permitted pressure exceeding that the boiler could endure with stays of such low factor of safety. It was also shown that the rules governing locomotive-boiler inspecting were disregarded by the company's employees assigned to make and certify to the reports required by law.

A report stating that the safety valves had been set was sworn to on Mar. 16, whereas this work was being done when the explosion occurred, and in addition it was proved that the inspector had failed to witness the inspection of the steam gage, although he certified under oath that this work had been done.

The railroad company was severely censured for permitting such reports and inspections to be made, and for allowing such important work as setting a safety valve to be conducted by an employee of whose experience or judgment, the testimony showed, it was utterly ignorant. The company was also blamed for keeping a boiler in service whose factor of safety was below standard.

In the opinion of the inspectors, the laws governing the inspection of locomotives and the setting of safety valves were sufficiently comprehensive for safety if intelligently complied with, but as an extra precaution action was taken to compel using a second gage always in view of the person setting the safety valve, and cleaning the siphon pipe and its connections every time the gage is tested.

With these additional inspection requirements, locomotive boilers should be well guarded and the danger from explosions reduced to a minimum, but of what advantage are the most stringent laws if they are not properly complied with or enforced by the proper officials? Under similar conditions other accidents, equally as bad or even worse, might readily occur. If safety is desired the laws must be rigidly enforced. The inspector must be competent and, above all, trustworthy. Ignorance of his qualifications does not relieve his employer of blame, and a company guilty of criminal negligence should pay the full penalty of the law.

What kind of inspection will allow a boiler to be operated with a factor of safety so much below the standard and, worse still, allow a man to tamper with a safety valve who evidently was so ignorant of the requirements or precautions to be observed? We have not heard of any penalty inflicted for such a flagrant case of negligence and disregard of the spirit of the law, but if the death of twenty-six human beings is not enough to incite some action stronger than censure by an inspector, then all the laws that have been and could be formulated on boiler inspection will be of very little use.

The laws must be enforced and the punishment made compatible with the infringement, or just such disasters as that at San Antonio will continue to discredit engineering practice in this country.

Fallacy of Submerged Flotation

The recent loss of the "Titanic" has revived the old discussion as to whether objects sinking in great depths of the ocean go clear to the bottom. That there ever could have been any belief that they do not, seems attributable only to our greater familiarity with the action of bodies floating in the air, and our failing to recognize the incomparability of air with water flotation.

They are incomparable for the reason that air does exhibit variation of density with height due to its compressibility, while to all intents and purposes water is incompressible; hence its density does not sensibly increase except at tremendous depths, and then not sufficient to support objects which have sunk entirely beneath the surface.

Even considering a sinking body of closely the same specific gravity as water, it is inconceivable that its structure could resist the enormous hydrostatic pressure at great sea depths sufficient to prevent its specific gravity from increasing faster than that of water as it continues to sink. Therefore, if anything, a body sinks faster the deeper it becomes submerged.

In this connection the letter under the same title on page 816 is of interest as it is from an authority on hydrostatics and gives a most lucid explanation why the submerged flotation theory is untenable.

Grate Distance from Boiler

How far should the grate of a return-tubular boiler be placed from the boiler shell?

In common practice, the distance seems to vary from 24 in. for anthracite coal to 40 in. for bituminous, with 36 in. as a good average, according to the coal used. This distance is assumed to allow ample space for the thorough mixing of the gases and for producing complete combustion.

What happens when a furnace is improperly designed, in that the grate is too close to the shell, may be shown by a very simple experiment. Place a tin can over a gas jet and too far down into the flame and a similar condition exists. The metal will become coated with soot, showing that incomplete combustion has taken place, caused by the cooling of the gas.

When the boiler is set too close to the grates, the flame impinging on the fire sheet is cooled before the combustion is complete and dense black smoke is formed which issues from the stack. Generally this smoke is attributed to lack of air, and probably many times that is the true cause, but the boiler shell too close to the grates would unquestionably have the same effect.

The results obtained from dutch-oven furnaces show that the gases of combustion should be thoroughly ignited before passing to the combustion chamber. All in all, this qestion is one worthy of the attention of those concerned: "Should the grate be farther from the boiler shell?"

In the accomplishment of many things there are several ways to perform them but the boiler room with only one exit offers only one means of escape. Does this include your plant?

Test of Cylinder Oil

By A. E. Walden

A given oil that will work well in one plant will not do so in another, even if the engine size, speed and pressure are the same, due to many conditions such as the structure of the iron entering into the cylinder, the method of the application of the oil, the acid or alkaline condition of the steam, etc.

In one plant under the writer's charge oil was first purchased costing 70c. per gallon; this was changed later to 50c. per gallon with the same operating results, and in neither case did the intermediate cylinder indicate oil by the use of filter papers or otherwise, yet it was always smooth and glossy. After trying several oils one was finally secured that cost about 30c. per gallon and actually reduced the oil consumption to one barrel per day. Specific gravity, flash and fire test are not always to be relied upon as an indication of good oil.

The test records, Figs. 1 and 2, show these determinations for two oils that were selected after numerous operating tests had been made and of which a sample, No. 75, was selected for further test. This oil from the specific-gravity test answered the purpose for a short time only, a certain time apparently being required to cut out the old oil and remove the polish from the cylinder. This cylinder had been lubricated with one-half the amount of oil, known later as No. 100, to keep it from knocking that was required with the No. 75.

With No. 75, Fig. 1, the flash point was so low in the friction-testing apparatus that it took fire and the test could not be carried out as was indicated for No. 100. Both oils cost 30c. per gallon.

temperature, as was shown after superheaters had been installed and the temperature raised for some time from 385 to 425 deg., the operating pressure being about 125 lb.

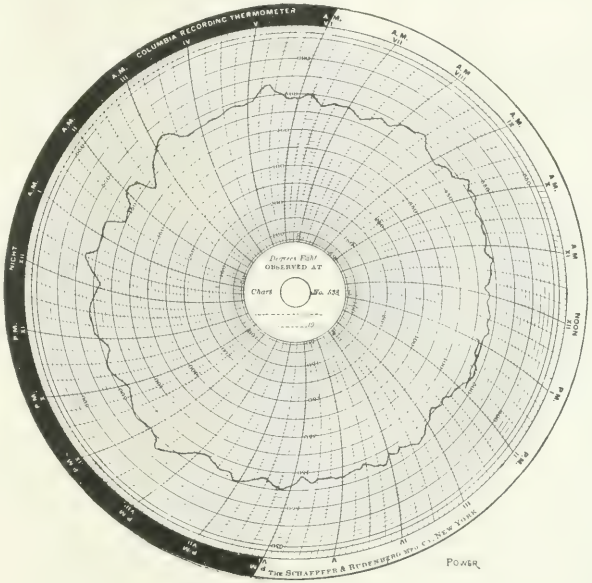


Fig. 3. Temperature Chart

No trouble has been experienced, and the quantity of oil has not been changed, which is eight drops per minute for No. 100. It required from 24 to 26 drops per minute of No. 75 to keep the valves quiet on this unit, which was a Corliss pumping engine having a 16x30-in. high-pressure, and two 24x30-in. low-pressure

so as to secure a uniform rise, as some oils, if the temperature is raised rapidly, will have the flash point reduced. The temperature rise should be made at about 20 deg. per minute, applying the test flame every 7 to 10 deg., but experience will determine the exact rate of rise.

Among the friction-testing machines there is one with bearings having a loading capacity of 6000 lb. and provided with a thermometer and pipe connections for supplying steam. This machine maintains the temperature in the bearings at

#75 OIL ANALYSIS.

MAKE OF OIL #75 DATE
KIND OF OIL Cylinder COLOR Red & green
DENSITY AMOUNT OF FEED OF OIL C. C.
VISCOSITY AT 70°F. 160 212°F. ASH %
FLASH POINT 560 °F. FIRE TEST 605 °F.
COEFFICIENT OF FRICTION AT °F TARR none %
COLD TEST 45 °F. SOAPY MATTER %
LOST BY EVAPORATION 12 HOURS AT 140°F. % SP. GRAVITY 25.4
ANIMAL ACIDITY none TALLOW 6.00 %
MINERAL ACIDITY none □ FT. RUBBING SURFACE
NO. REVOLUTIONS PRESSURE IN RUBBING SURFACE LBS. PER □ IN. 50/100
NO. FT. TRAVELLED BY RUBBING SURFACE
ELEVATION OF TEMP. °F ABOVE INITIAL TEMP. OF °F.
CHEMIST

Fig. 1

#100 OIL ANALYSIS.

MAKE OF OIL #100 DATE
KIND OF OIL Cylinder COLOR Reddish green
DENSITY AMOUNT OF FEED OF OIL C. C.
VISCOSITY AT 70°F 182 212°F. ASH %
FLASH POINT 560 °F. FIRE TEST 600 °F.
COEFFICIENT OF FRICTION .054,06 AT 350 °F TARR none %
COLD TEST 47 °F. SOAPY MATTER %
LOST BY EVAPORATION 12 HOURS AT 140°F. % SP. GRAVITY 26.0
ANIMAL ACIDITY none TALLOW 6.20 %
MINERAL ACIDITY none □ FT. RUBBING SURFACE
NO. REVOLUTIONS PRESSURE IN RUBBING SURFACE LBS. PER □ IN. 50/100
NO. FT. TRAVELLED BY RUBBING SURFACE
ELEVATION OF TEMP. 350° °F ABOVE INITIAL TEMP. OF °F.
CHEMIST

Fig. 2

Results of Oil Analysis

As shown by Fig. 2, the temperature specified in the test was to be 410 deg. This was not reached because of the type of thermometer used, but a temperature of 350 deg. was attained and the oil was and is able to stand a much higher cylinders. When the steam temperature was raised by means of superheaters, the amount of oil was not changed and the cylinders are in good condition.

In making the flash and fire test, the oil temperature was raised very slowly, the same point as the oil would be used in the cylinders, and at as near the test conditions as possible. From the writer's experience, however, there appears to be a field for a good cheap steam-heated friction-testing machine.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Center Crankpin Oiling Device Improved

The crankpin on a new high-speed center-crank engine would heat without apparent cause. It would run nicely for a week or more and the engineer would feel that no further trouble was to be expected, when suddenly it would heat and smoke until it required very prompt action to prevent the babbitt metal from melting out. As the engine is of the inclosed type, the cause of this trouble was not promptly discovered. Examination showed that the brass ring into which the oil for the crankpin is delivered was not deep enough to hold sufficient oil for the required service.

As may be seen in Fig. 1, oil from an elevated tank is delivered through sight-feed *A* and nozzle *B* into the swiftly revolving ring *C*, but only a small part of it goes to the crankpin, while the remainder is thrown out of the ring against the oil guard. Undoubtedly the best remedy for this defect was to remove the ring *C* and substitute a new one, but this was out of the question on account of the labor involved.

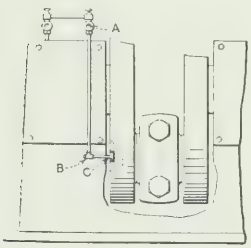


Fig. 1.

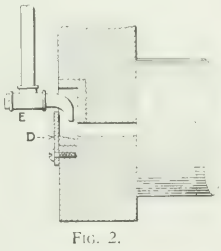


Fig. 2.

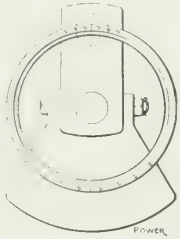


Fig. 3.

Crankpin Oiling Device

It was decided to add a ring cut out of sheet brass, the effect of which is shown at *D*, Fig. 2, thus making the cavity deep enough to fully cover the hole through which oil must flow to the crankpin. It was made in halves and secured in place by 14 screws, as shown in Fig. 3. For about one-half of the circumference it was impossible to use screws, because there was not sufficient metal in the original ring to hold them; hence the two metals were soldered together, and an oil-tight joint secured. It is practically impossible to put on such a ring so that it will run true; therefore it was cut smaller on the inside than required.

A cross feed from a lathe with a tool post carrying a suitable tool was fastened to one of the main bearings, the engine run at its lowest speed, and very light cuts taken from the flat brass ring until it was so enlarged as to admit the oil nozzle without friction, as shown in Fig. 2; this secured a perfectly true circle.

The oil pipe shown in Fig. 2 is fitted with a tee at *E* instead of an ell. By removing the plug shown, a wire can be inserted to clean out any foreign matter in the tee and nozzle.

W. H. Wakeman.

New Haven, Conn.

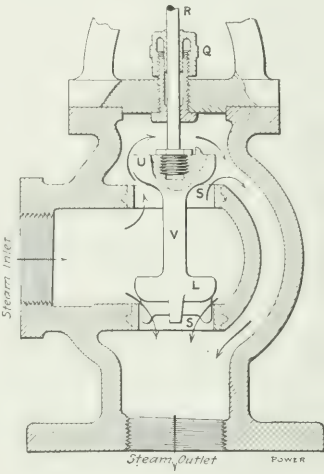
Remodeling a Defective Governor Valve

The accompanying illustration represents the valve-chamber and the valve of an automatic throttling speed governor. In experiments made, I found that the outside valve actuating mechanism (which automatically moves or holds the valve *V* in position in relation to the valve seats *SS*, thereby regulating the quantity of steam allowed to enter the steam chest of the engine) was considerably disturbed by the fluctuating steam-chest pressures acting on the valve stem *R* at the stuffing-box *Q*, especially at high steam pressures.

Circumstances compelled me to seek a means of neutralizing the effect of the constantly varying force exerted at this point, which caused the governor to dance, and sometimes to race. The valve in action is supposed to be automatically held in position in relation to its seats by maintaining the balance of two opposing forces, viz.: the centrifugal force of revolving weights and the centripetal force of springs under tension. Disturbing the balance of these forces will cause the valve to be moved, according to the direction of movement of the greater force.

The steam-chest pressure exerted against the valve stem at the stuffing-box *Q* tends to disturb the action of the above forces.

If this third force be of constant amount it will have no ill effect on the regulation, but as the steam-chest pressures of all throttle-governed engines vary considerably, it causes trouble with the regulation.



Throttling Governor Value

The following explanation will show how this force was made constant for a given boiler pressure: The top piston *U* of the valve was made larger in diameter than the bottom piston *L*, the increase in cross-sectional area amounting to the exact equivalent of the valve stem *R* cross-section. Thus when the valve *V* closes the governor ports there will be an upward force exerted upon the valve-actuating mechanism (not shown) of 13 lb. (boiler pressure 175 lb.) from the steam pressure acting on the differential surface of the top piston *U*. When the valve is fully opened and the boiler pressure is on the delivery side of the valve, there will still be 13 lb., but in this case from the pressure at the stuffing-box.

With 175-lb. boiler pressure, and with varying pressures on the delivery side of the valve, the sum of forces from the top piston and the valve-stem stuffing-box always equals 13 lb., increasing at one of these points in proportion as it

decreases at the other. This amount varies only as the boiler pressure rises or falls. The tendency of the governor to dance or race from the effect of fluctuating steam-chest pressures has thus effectively been overcome.

L. J. WATSON.

Port Huron, Mich.

What Should Be the Crank Positions?

At a large pumping plant where I am employed, we have two cross-compound horizontal Corliss pumping engines with unusual water ends in that they are designed as if driven by a cross-triple steam end. The intermediate crosshead has no steam cylinder, being driven by a connecting-rod from the intermediate crank on the shaft, which has two flywheels. What relative position should the cranks have to each other?

If there were three steam cylinders, I would say the cranks should be 120 deg. apart, but as the intermediate crank has no steam cylinder it receives energy from the shaft and flywheels; therefore I believe that the high- and low-pressure cranks should be set at 90 deg. and the intermediate at 135 deg. Perhaps other readers will express their opinions on this subject.

C. E. ALDRICH.

Tranquility, Calif.

Continuous Flue-Gas Sampler

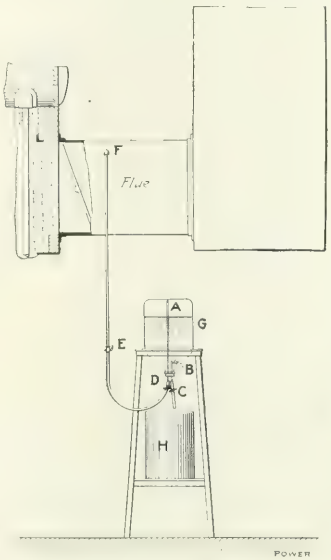
The accompanying illustration shows a simple but effective device used to obtain an average flue-gas sample for each day's run. The outfit may be constructed at small cost and it works very satisfactorily.

It consists of a 5-gal. glass bottle, *G*, mounted upside down on a wooden framework. Underneath the bottle is placed a metal can of about 6 gal. capacity. At a point in the flue, as at *F*, is inserted a ¼-in. iron or brass pipe reaching half way across the flue, with its open end so placed as to be directly in the path of the outgoing gases but not to interfere with the action of the damper. A preferable aspirating tube would be one extending all the way across the flue, and perforated with ⅛-in. holes every 6 in. apart, the holes being placed down so as to prevent the tube filling with soot.

A ½-in. pipe leads from *F* down to the level of the bottle with an air cock, *E*, at the bottom. Connection to the bottle is made by a heavy rubber tube, which may be closed by a pinch-cock, *D*. Into the mouth of the bottle is fitted a rubber cork having two holes, into which are inserted a ½-in. brass pipe *A* reaching to within $\frac{1}{16}$ in. of the bottom of the bottle, and into the other a short piece of pipe shown at *B*. On the outer end of pipe *B* is a short rubber tube which is fitted with a pinch-cock, *C*.

To use the sampler, fill the bottle with water, attach the short rubber tube, close the pinch-cock *C* and invert the bottle. The long rubber tube *D* is then connected to the cock *E* and the pinch-cock *D* opened. The pinch-cock *C* is then opened slightly so that the water in the bottle flows out one drop at a time into the pail *H*.

The gas will be slowly drawn from the flue into the bottle, and by regulating *C* so that the bottle empties in 8 hr. an average sample for the day's run may be obtained for analysis in an Orsat



FLUE GAS SAMPLER

apparatus. Before taking a sample of the gas, the air contained in the pipe and tube *E* should be withdrawn by producing a vacuum in it. The success of the sampler depends upon having all the joints air-tight.

B. S. NELSON.

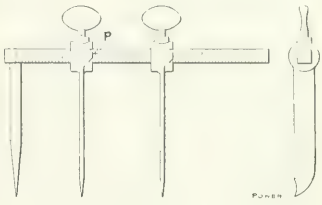
Bayonne, N. J.

Home-Made Gasket Cutter

The accompanying illustration shows a home-made gasket cutter which has given much satisfaction in our plant.

The beam was made of ½-in. square steel with a pointed leg secured at one end. The knives were made of tool steel with a square hole and thumbscrew in the hub as shown. After the knives have been fitted to the beam and ground, secure one to the beam and scribe a circle; then place the other at exactly the same place on the beam, with regard to the pointer *P* and bend the knife so that it will scribe a circle of the same diameter as the first. This is necessary in order to have both knives cut true to the same graduations.

As each inch on the beam means two in the diameter of the gasket, the half-



GRADUATED GASKET CUTTER

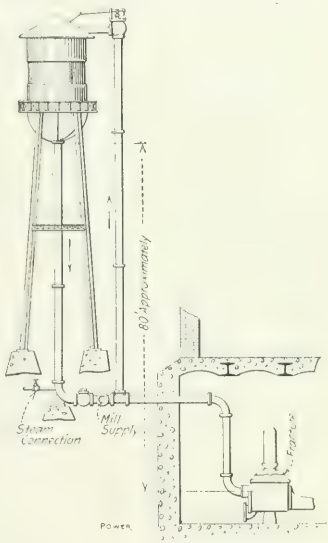
inch lines should extend all the way across the beam and read 1, 2, 3, etc.

O. O. LEMON.

Bristol, Va.

Impact of Water Broke Pump

A rather peculiar break happened in our plant recently. The pipe from the supply tank was not sufficiently protected where it is connected to the tank, and in the cold weather it would freeze at



PIPING ARRANGEMENT OF FRACTURED PUMP

this point. As this was a rather difficult place to get at, I decided to put steam in at the bottom of the pipe in order to thaw it. It worked successfully and we had occasion to make use of it some 8 or 10 times during the extreme cold weather.

Referring to the illustration, it will be seen that the pipes to and from the tank are on one line, but the check valve prevents the water from entering the tank at

the bottom. When the steam is turned on, the pump is run slowly, the pressure keeping the check valve closed, so that the steam has no outlet except through the tank. During the last cold spell the pipe was again frozen; the steam was turned on as usual, but in a short time there was a violent crack and the basement was deluged with water. It took but a minute's work to locate the trouble and get the water shut off; then I found that the air chamber, which is cast integral with the valve bonnet, had been broken off, and also the greater portion of the bonnet. As to what caused the break, we must conclude that the pump had stopped, or at least was going so slowly that the water receded, leaving the pipe empty.

The ice gave way suddenly, allowing the water to drop in a body, producing a ramming effect when brought to a stop at the pump. It was evident that considerable pressure was exerted, as the casting was fairly good.

S. M. QUINN.

Hudson, N. Y.

Saving Pump Rods

There are conditions under which it is impossible to prevent piston rods from scoring, and this is especially true with a steam pump of the type and size usually found in the average power plant. At best, the steam pump receives but little attention on account of its reliability and extreme simplicity, and often the gritty nature of the liquid pumped will flute a piston rod in a short time.

I once had a duplex receiver pump which was used to take the return water from a number of machines and elevate it to a tank a short distance above it where the water was used to supply the boilers and for other purposes.

As all of this equipment was new there was considerable sand, scale and other grit in the pipes and machines and in time this came back to the receiver and then to the pump, where it soon scored the steel rods at the water end. As the pump was in use almost constantly, all we could do was to pack the rods as often as was necessary and wait for the time to make the repairs.

The steam ends of the rods being in good condition, I thought that bronze rods could be substituted at the water end, but the construction prevented this. I found some 1⅛-in. brass tubing which was of the same outside diameter as the piston rods. After the rods were removed from the pump they were put in the lathe and turned down on the water end to 1⅞ in., beginning at the taper and continuing to about a half inch from the crosshead. I then lubricated the rod with white lead and started the tubing, and by ramming it gently against a post I soon had it up about an inch from the shoulder, when I put it in the lathe and cut the end of the tubing off where it was to fit against the shoulder at the crosshead end.

Then after driving the tubing home, the other end was cut off in like manner so that when the water-piston head was snug up on the taper it would also be snug against the end of the tubing.

To facilitate repairs, both rods were turned so that both pieces of tubing would be the same length, and a record of this was entered in the log for future reference. In case of renewal it is only necessary to split the old tubing to remove it, slip a new piece of the required length on in place of it and the rod is as good as a new bronze rod.

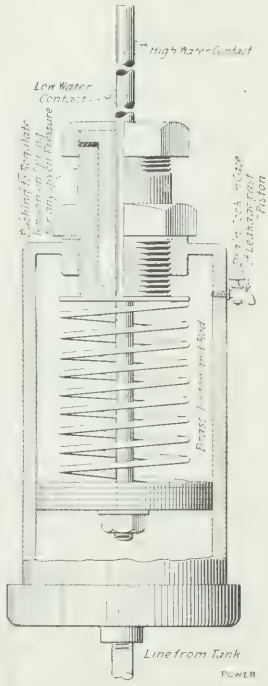
The cost of the tubing for this job was 35c., and the pump was out of service only about six hours.

G. H. WALLACE.

Racine, Wis.

High and Low Water Alarm

The accompanying illustration shows a device for indicating the quantity of water in our sprinkler tank. It is used both as a high and low water alarm,



SHOWING MECHANISM OF ALARM

and is not so liable to disorder as the common wire-and-float arrangement. The device should be mounted in a conspicuous place in the engine room so as to be readily seen by the engineer. The weather does not affect it as is the case with arrangements exposed to low temperatures where ice gathers on the pulleys and chains, preventing satisfactory operation.

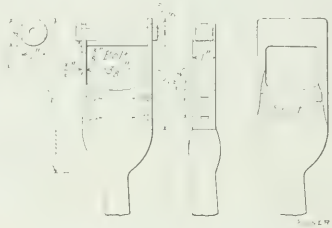
The device may be set at any desired pressure and made from pipe fittings. Its cost is very low and the advantages from its use more than compensate for the cost of the installation.

H. PREW.

Montreal, Can.

Repairing a Scoop Handle

The accompanying illustration shows how a scoop handle was repaired that had broken as shown in Fig. 2. The side pieces are of mild steel, but wrought iron will also answer the purpose. They are held in place by screws, as shown, but before the screws can be driven in the hardwood handle, it is necessary to



SHOWING REPAIRS TO SCOOP HANDLE

drill holes a little smaller in diameter than the screws.

The grip or roll is made of maple turned up in the lathe, with a hole through the center for a ⅜-in. bolt. Two opposite sides of this roll are planed almost flat, as shown by the dotted lines in the end view of Fig. 1. It is then finished with sandpaper.

FREDERICK L. JOHNSON.

Paterson, N. J.

Some Good Kinks

When renewing small round disks from globe valves, do not try to dig out the old ones. Just hold the disk in or over a flame—a match, or gas get, or torch—until it is softened by the heat; then it may be dug out with ease.

When packing valve-stem or other stuffing-boxes with twist packing, do not use a knife to cut it off, for it is next to impossible to do this without disarranging the packing and fraying the ends; use a pair of stout, sharp shears or a pair of snips.

When filing for a finished surface it is exasperating to have a bit of metal imbed itself in the file and on the next stroke dig a deep groove. To prevent this, clean the file carefully and give the entire face a coating of chalk. If cleaned and chalked from time to time, it will be found easy to get a finely smoothed surface.

When forced draft is used with some kinds of water-tube boilers, ashes blow out between the headers and occasionally sift down through the crevices around the door. This has been obviated in some cases by filling in between the headers with asbestos.

One morning an engineer discovered that the lower bolt on the wristpin wedge of the Corliss engine was broken. The wristpin had to be backed out, the crosshead moved away, the old bolt removed and a new one put in, and then the whole thing assembled and adjusted. By dint of hustling and some intelligent assistance he was ready to start in 10 minutes after the discovery. Strange to say, no small part of the aforesaid intelligent assistance was rendered by a person at that time many miles away. A former engineer had taken pains to slot the ends of all wedge bolts, so that in such an emergency they could easily be backed out.

When setting up on a gland, it is customary to adjust it so that it shows equal opening all around the stem or rod. This perhaps is satisfactory, if it is known that the rod is central. However, in the case of a rod that is not central—for instance, a rod of an engine whose piston is down—if the gland is adjusted to show equal opening on the outside, there is danger of making the gland rub on the inside. The safest way in all cases is to use a feeler to see that the gland clears the rod at all points. A feeler made of ordinary pipe covering band has been used with success.

WILLIAM E. DIXON.

Malden, Mass.

Air Pump Diagrams

The accompanying indicator diagrams, Figs. 1, 2 and 3, were taken from an air pump used in connection with a vacuum-cleaning system. The cylinder has a 19-in. bore and a 12-in. stroke and is driven 150 r.p.m. by a 25-hp. motor. A 40-spring was the only one available for taking the diagrams; and it was possible to connect to one end only of the cylinder. The inlet valves are of the Corliss type driven by a crank outside the flywheel on the end of the main shaft; there are five discharge valves of the poppet type.

The diagram shown in Fig. 1 was taken with the machine running at full speed and the cleaning-out valve on the dry separator open. The suction pressure being atmospheric, less pipe friction was present, and the only work done was that required to compress the air enough to open the discharge valves as shown at *X* in the diagram. The drop in pressure at the beginning of the suction stroke *Y* is caused by the suction valve not opening exactly on the center.

The diagram, Fig. 2, was taken with the machine carrying its regular vacuum —no cleaning tools were used—the automatic unloading valve being open just enough to prevent the vacuum from going above the proper point. When in good condition this valve should regulate within 2 in., but here it showed a variation of about 8 in. and a vacuum of 20 in. on the mercury column. There appears to be very little work done at this time as the compression line follows the suction line back over one-half the stroke.

The diagram, Fig. 3, was taken while

FIG. 1. CRANK END; NO VACUUM

FIG. 2. CRANK END; VACUUM 25 IN.

FIG. 3. CRANK END; VACUUM 12 IN.

FIG. 4. BROWN ENGINE DIAGRAM

using the cleaning tools, the working vacuum being about 12 in., as shown by the mercury column, and indicating that a large volume of air was being pumped.

The diagram shown in Fig. 4 was taken from a 16x42-in., four-valve, flat, multiported Brown engine, each set of valves being driven by a separate eccentric; the camshaft has been in service over 30 years. The engine was running badly at the time of taking the diagram. Will some interested reader tell me what should have been done to properly set the valves?

J. CASE.

Hyattsville, Md.

Engine Bedplate Repair

Recently a crack became visible in the bedplate of our engine, and soon caused excessive vibration of the main bearing. We could not shut down as this was our only engine, so we made the repair shown in the illustration.

Using a 20-in. iron bar, flattened at one end and threaded at the other, we cut a slot in the front of the bedplate to allow the flat bar to pass through. As a handhole was convenient we clamped the bar to the bedplate and then drilled through the plate and the bar; the bar was then fastened with two 1-in. bolts. By tightening the nut on the end of the bar at the front of the bedplate, the broken parts were drawn together.

The entire repair was made without stopping the engine, and after three months' service in carrying the usual

CRACKED BEDPLATE, SHOWING METHOD OF REPAIR

load the crack shows no signs of further extension.

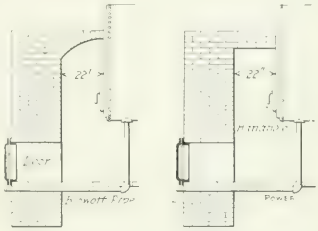
H. LOCKE.

Manchester, England.

Would the Arch Affect the Boiler's Operation?

Will some reader advise me as to the setting, form and effect of different shaped arches in the combustion chamber of a 60-in. horizontal tubular boiler?

In a plant where the original arches



FURNACE ARCHES

were circular in form they disintegrated and fell, and square arches were substituted. The illustration shows the two forms, Fig. 1 the original arch and Fig. 2 the new arch. Would the square arch have a deleterious effect on the draft and combustion in the boiler?

W. G. SEARS.

Alberta, Can.

Air Moisture Separator

At our plant there are a number of small air lines exposed to the outside atmosphere. During very cold weather the moisture in the air would freeze and give trouble; it sometimes took two days to thaw out the frozen lines.

To overcome this difficulty I made a separator out of a 5-ft. piece of 10-in. pipe, and ordinary 10-in. caps were used to close the ends of the pipe. The top cap was drilled and tapped for a safety valve and for the inlet and outlet air pipes. The inlet pipe extended about half way into the separator and the outlet was taken direct from the cap. A ½-in. line with a valve was connected to the bottom cap to drain off the condensation.

WILLIAM KELLEY.

Brooklyn, N. Y.

Questions Before the House

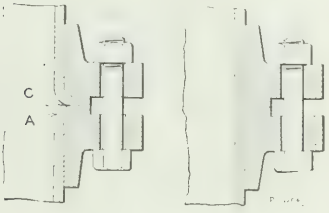
Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Reinforced Van Stone Joints

In the Feb. 27 issue, the writer of an article under the above heading takes the stand that nothing is gained in the way of efficiency in the new style, or reinforced van stone joint, basing his argument on a comparision of the theoretical tensile strength of the pipe and the combined tensile strength of the bolts.

From this point of view his argument is theoretically correct, but he has failed to consider that there are other than tension strains only to be dealt with in a van stone joint. I have never known of a flanged joint that failed due to the weakness of the bolts, while in one or two instances, at least, the old-style van stone joint has failed.

Fig. 1 illustrates the old-style joint and Fig. 2 is one type of the improved



OLD AND IMPROVED VAN STONE JOINTS

joint. There are a number of other modifications of the joint on the market, each with some particular advantage claimed for it; but the one shown in Fig. 2 overcomes all the practical objections to the old style.

In Fig. 1 the weakness of the joint is at *A*, the point of curvature. If the tension strain only on the pipe is considered, this would not be so as was proved in the article referred to, but a more careful analysis of the joint will show that all the vibration in the line is "centered" at the point *A*, with point *C* as a fulcrum. The flange as made in practice, is bored $\frac{1}{16}$ to $\frac{1}{8}$ in. larger than the outside diameter of the pipe in order to allow the flange to turn freely on the rough surface. This difference in the pipe diameter and the flange bore allows a small amount of play between the pipe and the flange, which in turn produces a vibrating strain at the point *A* caused by the constant vibrations present in all high-pressure steam lines. This constant vibration, even though it is slight, has a decided tendency to crystallize the metal at this point; the greater the vibrations the more rapidly will the metal crystallize. This defect is partially overcome by lengthening the hub of the flange, and it is simply a matter of time when the factor of safety in the original tensile strength of the pipe will entirely disappear.

Another defect in the old-style joint is the small water pocket formed over each gasket. Every practical man knows what it means to the joints to have water in the steam pipes. Where the flow of water is constant there would be no trouble as the water would be carried along with the steam, but where the flow is intermittent, as in plants operated ten or twelve hours a day, when the line is dead or the flow of steam stopped, a small amount of distilled water will collect at each joint. This will not only cause the joints to leak through the gaskets, but distilled water will attack iron and steel and cause corrosion to set in at this point.

W. LEE RAUECHE.

Birmingham, Ala.

Fallacy of Submerged Flotation

A subject which has excited the interest of many readers of the daily papers since the sinking of the "Titanic" is, whether or not a ship could sink to the bottom of the sea in a depth of 2000 fathoms. A short time before that disaster I presented a paper before the combined Civil Engineering and Mechanical Engineering Societies of the Massachusetts Institute of Technology, from which paper I will make some extracts, thinking that the subject might be of interest to POWER readers.

"Water is reduced in bulk by 1 per cent. when under a pressure of 3000 lb. per square inch, and this reduction increases in direct proportion to the pressure, so that there is a reduction of 10 per cent. at a pressure of 30,000 lb. per square inch.

"Applying this value to the density of the ocean at its greatest depths gives this compression in a different form. There is a depth of 31,614 ft. (5.9 miles) in the Western Pacific Ocean, where the pressure would equal 13,752 lb. per square inch, or 942 atmospheres; the weight of a cubic foot of sea water would there be increased from 64 lb. at the surface to about 67 lb. at the bottom. This increased density of the ocean in the lowest depths does not, however, prevent the sinking to the very bottom of anything that once starts in that direction.

"There is a popular idea that submerged objects continue to sink only until they reach a certain pressure, which is supposed to have some relation to their specific gravity, when they will sink no lower, but will be carried by undersurface currents here and there, until they finally reach some Sargasso Sea of wreckage. It may be safely assumed, however, that anything that will sink in a glass of water will sink to the bottom of the sea, for, as the depth and the pressure increase, the sinking object is subjected to so intense a pressure externally that compression and even implosion occurs, and it is reduced to so small a bulk that its specific gravity is greatly increased."

JAMES W. NELSON.

New York City.

Unnecessary Risks

The editorial "Unnecessary Risks," in the Apr. 30 issue, mentions entering ashpits under a bright fire, which brings to mind a task that was occasionally performed on board ships a few years ago; only in this case it was a necessary risk.

When a boiler tube gave out before the patented tube stoppers came into use, a sure and quick repair was necessary. The illustration shows the method of plugging a Scotch marine boiler tube.

PLUGGED BOILER TUBE

Pinewood plugs *A*, tapered to easily enter the tube ends, were carried and one plug had to be put in from the combustion-chamber end. The plugs were bored to receive a rod *B* threaded at each end and nuts and washers secured both plugs in place, thus cutting out the leaking tube and making it possible to keep the boiler in service until a new tube could be put in.

It was quite easy to place the plug at the front end, but not so at the back end, for the engineer had to enter the furnace under the nest of tubes, in which the leak was located, to put in the plug. The fire was smothered with green fuel, and placing a plank laid on top of it, and

crawling on his hands and knees, a pine plug in one pocket and a nut and washer in the other, the engineer entered the combustion chamber. He quickly placed the plug on the rod, which was already pushed through from the front end, and tightened the nut and plug in place, the final tightening being done from the front end.

On again entering the boiler room the engineer was covered with a blanket to prevent a severe chill. Sometimes after coming from a hot boiler furnace a man faints when he strikes the cooler air of the fire room, even though it may be as high as 115 deg.

The success of the job lies in keeping one's head long enough to enter the plug and screw on the nut. It does not take many seconds to do it if proper preparation is made, but everything must be just right, and there must be no bungling with either the plug or nut, for the heat is intense and more or less steam and water are spattering over the operator; for this reason an engineer performs the job.

CHARLES J. MASON.

Scranton, Penn.

Boilers Transfer Water

I once had boilers transfer water as described by Mr. Warner in the issue of Apr. 9. The plant contained four return-tubular boilers of 200 hp. each. the feed pipes entering through the top and extending down between the tubes below the water line, terminating in a tee with a piece of perforated pipe screwed in each end.

It seemed to me that No. 1 boiler was a rapid steamer, for immediately after the fire was cleaned in No. 1 furnace the stop valve on the other boilers would require partial closing to keep water in No. 1 with the pump working, and if the pump was stopped the water would go down in No. 1 and rise in the other boilers. The check valve appeared to be all right, but I took it out and replaced it with a new one. After that there was no more transfer of water.

The cause of the trouble is obvious: No. 1, being hotter than the others, owing to its clean fire, carried a slightly higher steam pressure which forced the water up the feed pipe, through a defective check valve and into the other boilers. I would advise Mr. Warner to keep the feed pump going with water near the middle gage and grind or replace the defective check valve.

N. R. WATKINS.

Merritt, B. C.

Answering W. E. Warner's problem under the above title, in the Apr. 9 issue, I think he will find a leaky check valve on the boiler-feed line leading to No. 2 boiler. It is impossible for the water to go over the U-bend back into No. 1 even if No. 2 primes, especially if either engine is in operation. Mr. Warner does not show a diagram of the feed line from the pump, but his trouble must be there. I had the same thing happen on a pair of boilers I was once operating, and after studying the matter for some time, I put in a new check valve and the trouble vanished.

The "other engineer" is mistaken in thinking No. 1 is the better steamer; the reverse is true. If No. 1 was the better steamer or the hotter, the water would not flow from No. 2 to No. 1 because the pressure would be a little greater in No. 1 and hold the water back. As it is, No. 2 is the easier steamer and is a little hotter, so it overcomes No. 1's pressure and sends the water through the defective check valve. The more water No. 1 gets, the cooler it becomes and the less its pressure. If there is no other connection, the trouble must be in the feed line.

There is a battery of two boilers connected similar to Mr. Warner's in our plant. The safety valves are set exactly alike; sometimes No. 1 will blow, sometimes No. 2. One of the firemen asked me why it was that "No. 2 always blows for him while No. 1 always blows for John."

I asked him which boiler he fired first and he said No. 1, and John always fired No. 2 first. One fireman was a right-hand and the other a left-hand shoveler. I explained that the hotter boiler would blow off first, the valves being set exactly alike, and No. 2 blew for the left-hand shoveler because he fired No. 1 first and invariably when he got to No. 2 he would think the boilers would stand a little more and would send in half a shovel of coal more into No. 2 than he had in No. 1.

I proved it to him in less than two hours by throwing half a shovelful more into No. 1 than No. 2; No. 1 blew the valve. The next day he unconsciously fired his old way and blew No. 2. I require the safety to be blown at least once in every 24 hours, not oftener if it can be helped, yet I do not complain if it blows twice.

C. A. SCOTT.

Wales, Wis.

A few years ago I was acting as water tender in a plant where the boilers were all connected to one header and were forced to their limit. We were using forced draft and great care was required to fire regularly and evenly, to avoid the trouble Mr. Warner mentions.

The chief engineer said that it was due to water being transferred from one boiler to the others. I never tried to prove it, and, like Mr. Warner, would like to know the cause of the trouble.

HAROLD J. WILKINSON.

Angola, Ind.

[The blowing of the high-water alarm mentioned by Mr. Warner is not due to a transfer of water from one boiler to the other. The higher water level, which causes the alarm to blow, is produced by a more energetic evaporation of the water in the boiler in which the alarm sounds.—EDITOR.]

Manila and Cotton Rope Transmission

My experience with rope drives may be of interest. In a cement mill, several of the departments were driven by three-cylinder vertical gas engines of about 280 hp. at 200 r.p.m. Each engine drove a line shaft through manila ropes with 9-ft. pulleys at about 40-ft. centers. The American or continuous system was used.

The ropes gave a great deal of trouble by swaying, especially if one of the cylinders was not acting properly, causing the engine to give a jerky motion to the rope. This swaying was so bad that flumes were built along the ropeways to keep the side-slapping within limits, and prevent the ropes from leaving the wheels, but the flumes kept them in place only fairly well as occasionally a rope would leave the pulley, get mixed up with the hub and shaft; then a new rope was necessary. This happened about nine times a year in the most troublesome drives.

Finally cotton ropes were tried with results that were highly satisfactory. The swaying almost entirely ceased, and one of the most troublesome drives now ran so quietly that the ropes resembled pipe lines.

E. D. GAGNIER.

Salem, Ohio.

Forces of Expansion and Contraction

On page 351 of the Mar. 12 issue, Mr. Ingham states that a gland joint inserted for expansion in a steam-pipe range between two boilers was blown out owing to the anchor bolts being improperly fitted and that this caused the boiler to be moved on its setting.

I am at present engaged upon an arrangement of steam piping and should be glad if Mr. Ingham, through POWER, would favor me with a sketch of the piping arrangement where this occurred as I have no wish to undergo a similar experience.

D. VARLEN.

London, N., England.

The instance mentioned in my article on the "Forces of Expansion and Contraction" in the issue of Mar. 12, was described in detail in a leading English engineering journal some years ago. Un-

fortunately, I am unable to find the description or illustrations. If, however, Mr. Varlen will take care to fit guard bolts to any gland-expansion joints he inserts in the pipe range, he need have no fear of undergoing a similar experience to the one referred to.

EDWARD INGHAM.

Manchester, England.

What the Diagrams Show

In the Mar. 26 issue J. F. Reynolds submitted a set of indicator diagrams taken from a compound pumping engine. He asked for a criticism on the receiver pressure carried and the distribution of work in the high- and low-pressure cylinders.

At first, the diagrams look excellent and the distribution of work nearly equal, and this would be the case if it were not for the high ratio of cylinder areas. The following calculation of horsepower delivered shows that the low-pressure cylinder is doing more than twice the work done in the high-pressure cylinder:

High-pressure cylinder

$$I.hp. = \frac{34 \times 2.5 \times 113 \times 30 \times 2}{33{,}000} = 17.5$$

Low-pressure cylinder

$$I.hp. = \frac{11.2 \times 2.5 \times 707 \times 30 \times 2}{33{,}000} = 36$$

making a total of 53.5 hp. Then,

$$\frac{36}{53.5} = 0.67 \text{ } per\ cent.$$

Thus the low-pressure cylinder is doing 67 per cent. of the work. If the cylinder ratio were 1 to 4, with the same size high-pressure cylinder and the same mean effective pressures, then the horsepower delivered would be 17.5 in the high-pressure cylinder and 23 in the low-pressure. This would mean a distribution of 57 and 43 per cent. respectively.

The ratio of areas is actually 1 to 6¼. Therefore to obtain equal work in the two cylinders the mean effective pressure of the high-pressure cylinder should be 6¼ times that of the low-pressure. This would mean that with the same total load as stated, the high-pressure cylinder mean effective pressure should be about 51.5 lb. and that in the low-pressure 8.25 lb. To bring this about, the high-pressure cylinder should cut off later and the low-pressure earlier, with a resulting receiver pressure of about 20 lb. gage.

If the engine were loaded up to rating, it is likely that the engine would automatically adjust itself to a more equal distribution of the load; the high-pressure cylinder would cut off later with a resulting increase in power; the receiver pressure would be higher, and the power delivered by the low-pressure cylinder would increase, but not in proportion to that of the high-pressure.

Mr. Reynolds remarks that, although there is very little compression, the engine runs smoothly. This is undoubtedly due to the slow speed of the engine and the effect of the water cylinders if they are connected tandem to the steam cylinders.

I notice also that on the crank end of the high-pressure cylinder, the release occurs at about ⅞ stroke. With the present point of cutoff the effect is slight, but with a later cutoff it might be well to improve this function.

LOUIS L. HEBBERD.

Chicago, Ill.

The volumetric ratio of the cylinders of this engine is

$$\frac{302}{122} = \frac{6.25}{1}$$

Therefore, for equal work the mean effective pressure of the low-pressure cylinder multiplied by 6.25 should equal that of the high-pressure cylinder. In this case, the average mean effective pressure of the high-pressure is 34.125 lb. and of the low-pressure 11.25 lb.; the ratio of work is

$$\frac{11.25 \times 6.25}{34.125} = 2.06$$

or the low-pressure cylinder performs 2.06 times as much work as the high-pressure cylinder.

If the engine is arranged with the cylinders in tandem, the distribution of work is of small consequence if the economy is good, but if it is a cross-compound, with its cranks at 90 deg. apart, the unequal work may cause an objectional and serious disturbance of the crank velocity.

If equal work is desired, it can be had by the following process. The indicated work shown is 53.69 hp.; thefore the mean effective pressure (total) referred to the low-pressure cylinder must be

$$\frac{53.69 \times 33{,}000}{706.86 \times 150} = 16.71 \text{ } lb.$$

To do one-half the work in the low-pressure cylinder, its mean effective pressure must be one-half of 16.71, or 8.355 lb., and for equal work in the high-pressure cylinder its mean effective pressure must be

$$8.355 \text{ } lb. \times 6.25 = 52.218 \text{ } lb.$$

The equalization may be had by adjusting the cutoff by means of the knock-off cams until the correct mean effective pressures are obtained in the diagrams.

Mr. Reynolds' comment relative to smoothness of operation with the small compression shown requires no comment except that, were it not for the danger of blowing through, a still further sacrifice might be advisable as it is well known that the resistance due to the head of water against which the engine works is usually ample for the cushioning of the reciprocating parts of the machine.

CHARLES F. PRESCOTT.

Philadelphia, Penn.

Mine Pump Blew Out Gasket

In the Apr. 2 issue, the sketch accompanying Mr. Saxe's letter does not agree with my experience with mine pumps. I have found that the relief valve should be closer to the pump than the check valve.

A mine pump similar to that under discussion is on the bottom of a 400-ft. shaft. The brass disk in the check valve was fastened to the arm with a bolt and nut. The nut came off, loosening the disk and wedging it in the end of the check valve, stopping the flow. If the valves had been arranged as in Mr. Saxe's sketch, there would have been a cracked air chamber or something more serious. The relief valve saved the pump and showed us where the trouble was located.

L. C. MOORE.

Ishpeming, Mich.

Breakage of Separator Gage-Glasses

Replying to H. L. Burns' letter under the above heading in the Apr. 16 issue, it is generally conceded that sudden temperature variations are the cause of such breakage, but I would like to know what theory Mr. Burns offers on his idea. I have considerable trouble and annoyance with gage-glasses breaking and will try out his suggestion, but I would like to know the fundamental reasons why the pipe assists in lengthening the life of the glass.

JOHN KLEMM.

Mexico.

A Troublesome Feed Pump

Replying to A. J. Berlin's letter under the above title in the Apr. 12 issue, my feed pump failing to supply enough water to the boiler, I opened the petcock on the water-end and was surprised to find a full boiler pressure. After closing the pump throttle valve and relieving the feed line of pressure, I removed the cap of the check valve at the boiler. It was found that the nut which holds the disk in place had unscrewed almost entirely from the stem.

The nut had three projections on its lower side, which held the disk while regrinding the valve. As the nut had become loose and the valve raised to allow the passage of water, the projections acted as impeller blades propelled by the water, thus unscrewing the nut until it rested on the bottom of the valve, preventing it from closing and the pump from doing its work. After tightening the nut and spreading the stem with a center punch, the valve was reassembled, and the pump ran without further trouble.

A. R. KUMMERER.

Hazleton, Penn.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Storing Bituminous Coal

What is the best method of guarding against spontaneous combustion of bituminous coal stored in a bunker?

H. B. L.

The bunker should not be filled over 10 to 12 ft. deep. Spontaneous combustion may be guarded against by any procedure that will keep the mass of coal cool. One means is to have the bottom of the bunker of plate iron cooled by natural or induced draft of air. Another is to have vent ducts near the bottom of the bunker with shields or covers arranged so that cold air may enter the vent ducts through the sides or bottom of the bunker and circulate up through the mass of coal.

Suitable Size of Feed Pump

What size feed pump would be suitable for a 1000-hp. boiler? How may the fire baffles of a B. & W. boiler be inspected?

L. A. S.

A 10x7x12-in. single or 8x5x12-in. duplex boiler feed pump would be suitable for a 1000-hp. boiler. The fire baffles of a B. & W. boiler may be inspected for leakage while the boiler is in use by opening one side dust door after another, and observing whether the flame passes through the baffles. When the boiler is not in use the baffles may be inspected by removing the top covering of the boiler and dropping a light down between the tubes.

Use of Exhaust Condensation as Feed Water

Can condensation from exhaust steam heating be employed as feed water without danger of burning boiler shell due to deposit of oil in boiler?

J. D. M.

It is very difficult to remove all traces of cylinder lubricating oil from the condensation, and when the feed water consists largely of condensation from exhaust, the latter is likely to deposit oil in the boilers, the amount depending on the combination of such conditions as kind and quantity of oil used in cylinders of engines, analysis of the original feed water, activity of boiler circulation, intensity of firing, etc. In many plants all of the condensation of exhaust that is recoverable is used as feed water without serious injury to the boilers, in most instances employing some method of removing oil from the exhaust steam or from condensation or both. But in any instance where exhaust from condensation has never been tried as feed water, it should be used sparingly at first and gradually increased as a proportion of the total feed water required, with frequent internal examinations of boilers for discovery of oil deposits.

Power Developed by Pumping Engine

How many indicated horsepower should be developed by a triple-expansion duplex direct-acting pump, each side having high-pressure cylinder 10 in. diameter, intermediate 16 in. diameter and low pressure 30 in. diameter by 24 in. stroke, supplied with steam at 125 lb. boiler pressure and operated condensing with a 26-in. vacuum and making 55 strokes per minute?

B. E. T.

Supplied with dry steam the pumping engine should develop 147 i.hp.

Siphons or Jet Pumps

What difference if any is necessary in proportions of nozzles in siphons to work by water in place of steam pressure?

E. G. H.

The main difference is that in jet pumps which are operated by water pressure, the passages for the pressure supply are larger in cross-sectional area and the reductions are usually made more abrupt.

Degree of Vacuum in Heating Coils

When a vacuum gage placed on the return receiver of a vacuum-exhaust steam-heating system indicates 20 in. vacuum, will there be the same vacuum in the heating coils?

T. B.

The vacuum in coils can never be the same as that of the receiver except while a coil, or radiator too small for its work, acting as a condenser, is becoming filled with water.

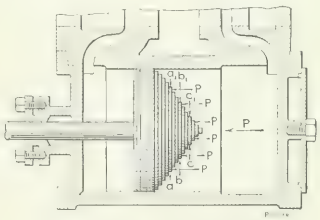
Pressure on Conical Piston

When the piston of an engine has a conical or curved surface which exposes a greater area to the steam than if it had a plane surface, why is it that in estimating the power developed, the piston area is treated as though it were a plane surface at right angles with the stroke of the piston?

F. B.

Steam within the cylinder of an engine exerts equal pressure on every unit of area of the exposed surface of the sides and head of the cylinder and of the piston. Regardless of the shape of surface thus exposed to pressure, the resulting total pressure exerted on any particular area, in any particular direction, is the product of the pressure per square inch by the area in square inches of the surface projected on a plane at right angles to the direction of pressure under consideration. Hence, the total force exerted on a piston by the steam in the direction of the stroke, is the pressure of steam per square inch multiplied by cross-sectional area of the cylinder in square inches.

A graphical analysis of the pressure of steam on a conical-shaped piston is given in the illustration. The conical surface may be considered to be made up of infinitely thin disks, similar to those of the drawing, increasing uniformly in diameter toward the base of the cone and the following would still hold true. The total pressure resolved in direction *P, P, P,* is effective on the exposed vertical surfaces of the disks, the total area of which is equal to the cross-sectional area of the cylinder. Any radial pressure like *a, b* or *c* against the edges of the disks is counteracted by equal and opposite pressure, as at a_1, b_1, c_1. Similarly, a piston of any other form may be resolved into equivalent surfaces parallel and perpendicular to the axis of the cylinder, and the effective area will always equal the cylinder's cross-sectional area.



PRESSURE ON CONICAL PISTON

The Phipps power plant, which has for years been furnishing light, heat and power to a group of Pittsburgh buildings, is now owned by the Duquesne Light Co.

Study Questions

This Week's Questions
Last Week's Answers

16. With the fewest cuts and welds, how can six pieces of chain be joined into one piece if two pieces contain two links; two, three links, and two, four links?

17. An engineer had a trench to cover, 12 ft. long by 2 ft. wide. He happened to have on hand a board 3 ft. wide and 8 ft. long. How could he completely cover the trench by cutting this board into only two pieces?

18. What will be the energy in foot-pounds in a blow from a steam hammer if the weight of the moving parts is 62 lb., length of stroke 8 in., diameter of cylinder 6 in. and mean effective pressure 90 lb. per square inch, neglecting friction and atmospheric resistance?

19. Having obtained the energy in problem 18, find the velocity of the hammer at the end of the stroke.

20. A cylindrical boiler shell is 66 in. in diameter by 16 ft. long. With 90 lb. gage pressure what is the total force tending to rupture the shell along one longitudinal seam?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

11. The volume of the engine foundation can be found by the prismoidal formula.

$$V = \frac{h}{6}(A_1 + 4A_m + A_2)$$

where

V = Volume;
h = Altitude;
A_1, A_2 and A_m = Top, bottom and middle areas respectively.

The problem gave

$h = 2$ ft.;
$A_1 = 2 \times 4 = 8$ ft.;
$A_2 = 3 \times 5 = 15$ ft.

The middle area is found by multiplying the means of the top and bottom lengths and widths.

$$\frac{2+3}{2} = 2\frac{1}{2} \qquad \frac{4+5}{2} = 4\frac{1}{2}$$

$$\frac{5}{2} \times \frac{9}{2} = \frac{45}{4} = 11\frac{1}{4} \text{ sq. ft.}$$

Substituting in the formula,

$$V = \frac{2}{6}(8 + 45 + 15) = \frac{68}{3} = 22\frac{2}{3} \text{ cu. ft.}$$

Multiplying by 125 lb., the weight of the foundation is 2832.5 lb. Adding the weight of the engine and dividing by the area of the base,

$$\frac{2832.5 + 650}{3 \times 5} = 232.16 \text{ lb.} =$$

the load per square foot on the floor.

12. Let x = the number of tons burned in April. Then $x \times \frac{x}{100}$ = gain in May = $56 - x$. Simplifying the equation,

$$\frac{x^2}{100} + x = 56$$

or

$$x^2 + 100x = 5600$$

This is a quadratic equation requiring for its solution the completion of a perfect square in the left-hand member, which is done by adding the square of one-half of the coefficient of the second term to each side of the equation, or

$$x^2 + 100x + \frac{(100)^2}{2} = 5600 + \frac{(100)^2}{2}$$

$$x^2 + 100x + 2500 = 8100$$

Extracting the square root of both sides,

$$x + 50 = 90 \text{ or } x = 40 \textit{ tons.}$$

This proves since 40 per cent. of 40 tons is 16 tons, the gain in May over April.

13. As during the first hour he would be carried west a distance of two miles, in traveling his first three miles he must take such a course toward the northeast as to arrive at a point which would be the apex of a right-angle triangle having a base of two miles, a hypothenuse three miles and consequently a perpendicular 2.236 miles long. As each hour of travel in the direction of the hypothenuse carries him 2.236 miles, then to be carried five miles would require

$$\frac{5}{2.236} = 2.236 \text{ hr.} = 2 \text{ hr. } 14 \text{ min. and } 9.6 \text{ sec.}$$

14. All of the forces acting on the ladder can be considered as acting about the base as a hinge and their moments (the products of the forces by their arms, which are the perpendicular distances between the lines of direction of the forces and the hinge center) must add up to zero. Two of the forces are vertical, the weight of the ladder and the weight of the man; the reaction of the wall is horizontal. The weight of the ladder will act through its center of gravity, which, since the ladder is of uniform weight, is 15 ft. from the end. The arm of this force will then be

$$15 \times \textit{cos. } 65 \textit{ deg. } 50 \textit{ min.}$$

From a table of natural trigonometrical functions

$$\textit{cos. } 65 \textit{ deg. } 50 \textit{ min.} = 0.40939$$

Then

$$15 \times 0.40939 = 6.14085$$

and the moment of the weight will be

$$62 \times 6.14085 = 380.7327 \qquad (a)$$

Similarly the arm of the force corresponding to the man's weight at 25 ft. from the foot of the ladder is

$$25 \times 0.40939 = 10.23475$$

and the moment

$$150 \times 10.23475 = 1535.2125 \qquad (b)$$

The arm of the reaction of the wall is the vertical height of the point of contact of the ladder from the ground, or

$$25 \times \textit{sin. } 65 \textit{ deg. } 50 \textit{ min.} = 25 \times 0.91236 = 22.809$$

and the moment

$$X \times 22.809 \qquad (c)$$

This reaction being opposed to the other forces

$$(c) - (a) - (b) = 0$$

or

$$(X \times 22.809) - 380.737 - 1535.2125 = 0$$

$$X = \frac{1915.9452}{22.809} = 83.9995 \text{ lb.}$$

And as action and reaction are equal, the pressure of the ladder against the wall is the same or approximately 84 lb.

15. Let x = speed of slower pulley. Then $x + 100$ = speed of faster pulley and

$$x + x + 100 = 110$$
$$2x = 10$$
$$x = 5$$

The speeds of the two pulleys are therefore 5 and 105 r.p.m.

Illinois N. A. S. E. Decatur Convention

A large number of delegates and friends attended the Illinois National Association of Stationary Engineers' eighth annual convention at Decatur, on May 23, 24 and 25.

Thursday's Session

The first session was opened on Thursday morning, by an invocation by Rev. W. H. Penhallegon, after which Mayor Dan F. Dinneen delivered a brief address of welcome, in which he touched upon the importance of the engineer in the community. He likened the power plant to the mainspring of a watch; when that fails everything else becomes idle and useless. National Secretary Fred Raven responded briefly on behalf of the association. Judge O. W. Smith spoke of the layman's ignorance of the engineer and his work.

National Vice-president John McGrath contrasted the high development of steam engineering with that of 30 years ago, and expressed the opinion that, although marvelous strides have been made, this is only the beginning of the progress yet to be made.

John Lane, editor of the *National Engineer*, said that the vast amount of reckless waste that has existed, and still does in some industries, was characteristic of the pioneer, but keen business competition and other causes are eliminating much of it. One of the main functions of the N. A. S. E. is to educate the engineer to conserve the raw materials with which he deals.

W. L. Osborne, secretary-treasurer of the Central States Exhibitors Associa-

ion, speaking for President F. E. Ramsey, who was unable to be present, told of the objects of the exhibitors and their association. State Deputy W. L. Parker expressed his pleasure in the healthy condition of the organization and the bright future in store for it, and Past National President Beckerleg told of the life- and accident-insurance department and the good it is accomplishing.

Local President E. R. Wortman then turned the gavel over to State President J. F. Alt, who appointed the various committees and declared an adjournment until 2 p.m.

At the afternoon session a proposed license law, prepared by a committee appointed last year, was taken up and approved with a few minor modifications. The law provides for a chief examiner and not less than eight district examiners who shall issue licenses to applicants after suitable examination. Anyone who wishes to operate a boiler carrying a pressure of 15 lb. per square inch or more, or a steam engine, or other piece of steam-driven apparatus of 15 hp. or more rated capacity, must first obtain a license.

At 3:30 the session was adjourned to permit a visit to the works of the H. Mueller Manufacturing Co., maker of plumbing faucets and valves, pressure regulators, etc.; also to the Decatur Ry. & Light Co. and the Decatur Brewing Co. plants.

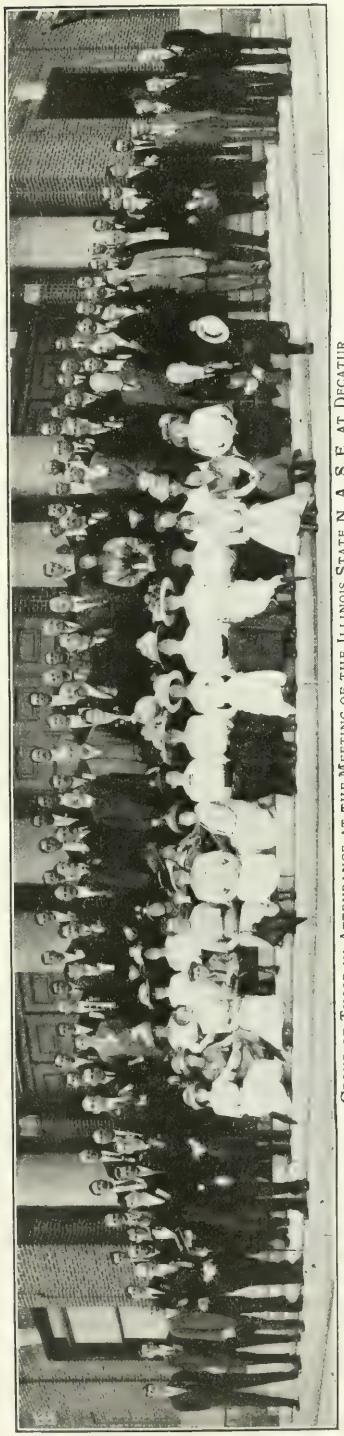
At the evening session, Mr. Freeman, of the H. Mueller Manufacturing Co., read a paper prepared by A. W. Cash, of the same company, on "Steam Pressure Reducing Problems," in which it was pointed out that the trouble with many of the reducing-valve installations was that too large a valve was employed. Where the steam pressure is reduced it is best to place the reducing valve as far from the engine as possible, thus reducing the effect of the pulsations caused by the opening and closing of the admission valves.

Fred Hickey, of the Dearborn Drug & Chemical Co., then told humorous stories and gave some laughable imitations.

Friday's Session

On Friday the delegates and friends took a 50-mile trip to Urbana and visited the University of Illinois. Dean Goss welcomed them and expressed the hope that the university and the engineers throughout the state might become more closely associated to the greater advantage of both.

Prof. S. W. Parr, one of the foremost fuel experts of the country, gave a short lecture on "Specifications for the Purchase of Coal." He showed the necessity of specifications where in many locations coals of widely varying compositions and fuel worth are available, though in many cases the specifications



Group of Those in Attendance at the Meeting of the Illinois State N. A. S. E. at Decatur

are unnecessarily complicated. The important thing is heat value and it is possible to draw simple specifications to give the purchaser reasonable protection.

Prof. Edward Bartow, director of the Illinois State Water Survey, gave a short discourse on "The Work of the State Water Survey with Special Reference to Boiler Water." The survey makes free analyses of water for sanitary purposes. It has analyzed a great number of waters for mineral content and has issued figures on the cost of softening them. Prof. Bartow showed how important it is to use a boiler-feed water which will not form scale, by stating that $\frac{1}{16}$ in. of scale on the heating surface means a fuel loss of 15 or 16 per cent., not to mention the repair costs made necessary by burned tubes, plates, etc. The visitors then inspected the fuel-testing and water-supply laboratories.

After luncheon in the Y. M. C. A. café the party assembled in the engineering lecture room where J. Paul Clayton gave a lecture on "A New Analysis of Indicator Diagrams," illustrated with lantern slides. By replotting a diagram on logarithmic paper it is possible, said the speaker, to ascertain the volumetric clearance very accurately, to estimate closely the steam consumption and to discover the presence of leaks as well as check up other important points as to the condition and operation of the engine. The university will shortly issue a bulletin fully covering this subject.

Prof. Leutwiler explained the method used in teaching power-plant designing. Each student is given a specific problem in which the controlling factors, such as the load curve, location, cost of fuel, etc., are given and he is required to lay out a suitable plant, make a general drawing and a piping plan.

Adjournment was then made to the students' drafting room, where some of the actual work was examined. In groups of half a dozen and under the guidance of the professors and some of the senior students, the party made a tour of the laboratories of mechanical engineering, electrical engineering and materials testing, the power house, blacksmith shop, machine shop, foundry and pattern shop. The visitors then returned to Decatur.

Saturday's Session

On Saturday morning the delegates assembled and after Rockford was selected as the place of the next annual convention, the following officers were elected: President, John Morgan, Association No. 3, Waukegan; vice-president, G. W. Hullinger, Association No. 16, Decatur; secretary-treasurer, W. E. Hill, Association No. 17, Rock Island, reëlected.

The new officers were installed by National Secretary Raven, and J. F. Farrell, ex-mayor of Ottawa, made an address

in which he strongly sympathized with the engineers and appreciated the obstacles which they encounter. He thought that it would be beneficial to have more public meetings so that the plant manager and owner might see what the engineers are doing, what they need and deserve, and would do all in his power to aid the Illinois State Association to bring about the enactment of the license law advocated by it.

Prof. E. C. Woodruff, of the James Millikin University, then talked briefly on higher education for engineers, after which the convention was adjourned.

The Exhibits

The exhibition hall, under the charge of the Central States Exhibitors Association, was well arranged and numerous effective displays were made. Those exhibiting were American Steam Gauge & Valve Manufacturing Co., V. D. Anderson Co., Crandall Packing Co., Decatur Railway & Light Co., C. A. Elliott, representing the George B. Carpenter Co., Dearborn Drug & Chemical Co., Faries Mfg. Co., Field & Shorb Co., Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Hills, McCanna Co., Home Rubber Co., Jenkins Bros., W. H. Jennings, H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., H. Mueller Co., Osborne Valve & Joint Co., William Powell Co., Power, Ralph H. Rawson, representing Anchor Packing Co., Maguire Rubber Co. and McMaster-Carr Supply Co., Schaeffer & Budenberg Manufacturing Co., Standard Oil Co., C. E. Squires Co., Wickes Boiler Co. and the United States Graphite Co.

Exhibit at Pratt Institute

The annual exhibit of the work of day students of Pratt Institute, Brooklyn, N. Y., will be held on Saturday, June 15, 10 a.m. to 5 p.m.; Monday, June 17, 10 a.m. to 10 p.m.; Tuesday, June 18, 10 a.m. to 5 p.m. This exhibit is public and affords those interested in industrial and technical education an opportunity not only of viewing the students' work in the various courses, but of inspecting the methods, the equipment and the general facilities of the school for conducting this training.

There are day and evening courses for both men and women in a great variety of vocational subjects, including fine and applied arts, architectural design and construction, household science and arts, library management, kindergarten training and technical and trade courses for men along several important lines.

The work of the School of Science and Technology is of especial interest to men engaged in technical and trade pursuits. This school provides instruction in applied mechanics, applied electricity, applied chemistry and tanning, machine work and tool making, carpentry and building and pattern making.

The twenty-fifth anniversary of the founding of the Institute will be celebrated with a dinner, June 15, to which all graduates and former students are invited.

Standards for Fittings and Valves Not Settled

A warning is being sent out by the committee of manufacturers on Standardization of Fittings and Valves, 30 Church St., New York City, not to specify or order flange fittings by the 1912 U. S. Standard for standard weight and extra-heavy flanges and flange fittings, adopted by the National Association of Master Steam & Hot Water Fitters. This standard has not been accepted as final by the manufacturers of flanged fittings and valves, and they state will not be accepted until certain necessary revisions have been made to suit the practical requirements of all concerned.

Before a new standard which deviates from the generally accepted practice for flanges and flanged fittings can be considered final, a number of important points must be carefully considered. In view of these considerations it is better to maintain the old practice until a universal standard can be agreed upon.

OBITUARY

Wilbur E. Richardson

On May 15, Wilbur E. Richardson, president and general manager of the Richardson-Phenix Co., Milwaukee, Wis., died of apoplexy at his late home, 875 Island Ave., Milwaukee.

Early in life, Mr. Richardson served his time as machinist in the Marionette Iron Works, Marionette, Wis. He early demonstrated his ability to cope with difficult problems in general power-plant work, and soon accepted the position of chief engineer of the Gilbert Paper Co., Menasha, Wis. The improvements and economies which he effected in this plant brought him into prominence and he was soon induced to enter the employ of the E. P. Allis Co., at Milwaukee, where he established an excellent record in this company's erecting and testing departments.

Later, while engaged in erecting pumping engines, Mr. Richardson conceived the idea of developing a mechanical cylinder-oil lubricator along new lines. He submitted his scheme to Edwin Reynolds, of the Allis-Chalmers Co., who thought so well of it that he gave Mr. Richardson his first order. The business was then established in a small way in Milwaukee.

In the fall of 1900, Mr. Richardson was sent to New York City to complete the installation of eleven 5000-hp. engine units in the Ninety-sixth St. station of the Metropolitan Street Railway Co. His successful work at this plant led to his promotion as the Allis-Chalmers Co.'s superintendent of erection for the Eastern district. Mr. Richardson took charge of similar large installations in the Manhattan Ry. Co.'s Seventy-fourth St. power station, the Interborough Rapid Transit Co.'s Fifty-ninth St. station and the Brooklyn Rapid Transit Co.'s Third Ave. power station. Upon the completion of these installations, Mr. Richardson was appointed general superintendent of all the work of the Westinghouse Machine Co.

In the meantime, the mechanical lubricator business which Mr. Richardson had established several years before had

W. E. Richardson

grown to such an extent that in 1907 he was enabled to sever his connection with the Westinghouse Co. and devote all of his time and energy to the design and manufacture of his company's products.

Mr. Richardson's inventive genius soon developed a number of important improvements for the economical application of oils to power-plant machinery, many of which are used today in the large power plants throughout the country.

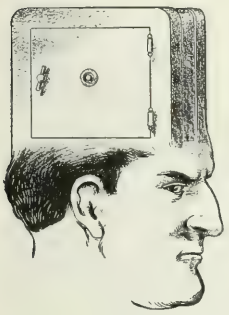
His foresight and excellent judgment caused him to surround himself with a business organization that is in such excellent shape today that his sudden taking away, while a great shock to his associates, will not in any way interrupt the business.

Mr. Richardson was endowed with a strong and genial personality which has gained for him wide and steadfast friendships throughout the country. He was a keen judge of human nature, and his memory will be particularly cherished by many engineers whom he had placed in good positions. He is survived by Mrs. Richardson and two sons.

POWER

Vol. 35 NEW YORK, JUNE 11, 1912 No. 24

Hoarding Knowledge Hinders Progress



LIKE money, knowledge is useful only when in circulation. Neither accumulates interest while locked in a safe.

He who keeps to himself the good ideas and useful things he has discovered in practice is either indifferent, mistakenly modest, or selfish. Operating engineering as a whole gains nothing from his work while he refuses to give others the benefit of his experience. Exchange of ideas is essential. Your ideas may help the other fellow, his may help you, and together they will surely help the younger chap still striving to make good.

"Power" the Clearing House

It is the definite scope and particular function of a technical paper to help solve the problems connected with its field and assist all who will be assisted —in short, to be a clearing house for practical, helpful ideas. That is "Power's" fundamental aim.

Ideas do not mean dreams, but suggestions as to how to overcome your fellow engineer's difficulties, what devices have been most effective in accomplishing certain things, why particular methods of operation are best under given conditions and when or where it is wisest to do this or that. Sometimes the description of a practical and efficient installation will indicate a change that will improve another. Short, practical articles are especially desirable. They are read, not laid aside, as are many of the long ones, for future reference. If concise and to the point they are almost certain to be of benefit to the average reader.

The ideal short article sets forth conditions and views of real value, gives valuable data, cites actual and accurate performances which will serve as a guide for other work, or, perhaps most important of all, contains kinks and new ways of doing things that are always helpful.

What to Write About

In choosing a subject do not forget heating and ventilating just because it is summer. Although the plants may now be idle, many things must be done to prepare them for the coming winter.

Refrigeration naturally suggests itself and contributions along this line will be welcome.

The electrical and gas power departments equally deserve your consideration. Practical hints on the operation of gas engines and producer plants, and all kinds of electrical machinery are always timely and we are looking for more material of this character from men who can write with the authority of experience.

If the subjects we have suggested do not appeal to you, then choose your own, but in some way take an active part in furthering power-plant progress. Remember, also, we want your questions and answers to other questions whenever you are minded to send either.

Let "Power" be the Bank of Exchange and use it as it should and would be used. You will get good interest on your investments and add to your own store of knowledge.

Making Charcoal Iron Boiler Tubes*

By George Thomas

History of charcoal iron, its qualities, the method of production and the process involved in the manufacture of boiler tubes.

*From a paper read by George Thomas, treasurer of the Parkesburg Iron Co., at the recent convention of the National Association of American Boiler Manufacturers.

The earliest iron was made by directing a blast of air on a hearth charged with charcoal and finely powdered ore. This crude hearth was later developed into the Catalan forge, which, although the charge has varied, is practically the same and produces the same grade of iron as the sinking fire of today. That the art was highly developed in early times and that the product has lasting qualities, are evidenced by the famous iron pillar of Delhi, a shaft 16 in. in diameter and 23 ft. high, forged about 300 A.D. However, the practice of sinking ore direct is a slow operation, requiring much charcoal, involving a heavy loss and demanding an ore with a very high iron content.

Passing from the Catalan forge, used primarily for reducing ore, next in order is the Lancashire hearth used in Sweden and the United States for converting pig iron. Here an oxidizing flame is used, and the purifying is largely effected by a strongly basic ferruginous slag surrounding the molten particles of iron. In sinking gray iron the pig is melted down before the tuyere, and collects in a slag-surrounded ball at the bottom of the hearth. This mass, not being entirely decarburized, is raised above the tuyere and again remelted through charcoal, when it collects into the final lump or loup.

On account of its lower silicon content, white iron in the Lancashire hearth can be converted in one operation, but on account also of its higher sulphur the product is inferior. To avoid the excessive labor and charcoal costs incident to sinking gray pig iron a preliminary operation was employed, namely, the finery or run-out fire. This consisted of a hearth with four tuyeres, where gray iron was melted in charcoal, the graphitic carbon changed to combined carbon and the silicon greatly lowered. The metal thus formed could be refined in one operation in the Lancashire hearth.

Having in a superficial way followed the conversion of ore and then pig in the forge fire, the conversion of wrought and steel scrap in a hearth of the same character will next be considered. This method of making charcoal iron is today used almost exclusively in America, and to a certain extent in Sweden.

After 1870, through the development of the steel process in this country, very desirable raw material for making charcoal iron was discovered in certain forms of steel scrap. A charge of this material corresponds to the mixture sunk in the Lancashire hearth at the second refining of gray pig iron. There is sufficient carbon to prevent undue oxidization of the iron and sufficient manganese to make a manganiferous as well as ferruginous slag, the first of which is needed to reduce the sulphur and the last to lower the phosphorus in the charge. There is no excess of silicon which in sinking pig iron often caused inferior charcoal iron through making a silicious slag, and consequently preventing the elimination of phosphorus.

In sinking steel scrap, although the charge may run 0.4 per cent. or higher in carbon, 0.6 per cent. manganese, 0.06 per cent. sulphur, and 0.12 per cent. phosphorus; the bloom will average under and will very rarely slightly exceed 0.03 per cent. carbon, 0.025 per cent. manganese, 0.02 per cent. sulphur, 0.04 per cent. phosphorus.

The forge fire usually employed today is run with a cold blast and one tuyere, and much depends on the skill and training of the forgemen. A hot blast saves charcoal and prevents some loss of metal, but it usually produces iron of inferior quality. Two tuyeres work faster and consequently prevent the forgemen from giving proper attention to sinking the mixture. The use of good charcoal, of which about 900 lb. is required to make from scrap a bloom ton of 2464 lb., is

FIG. 1. KNOBBLING FURNACE

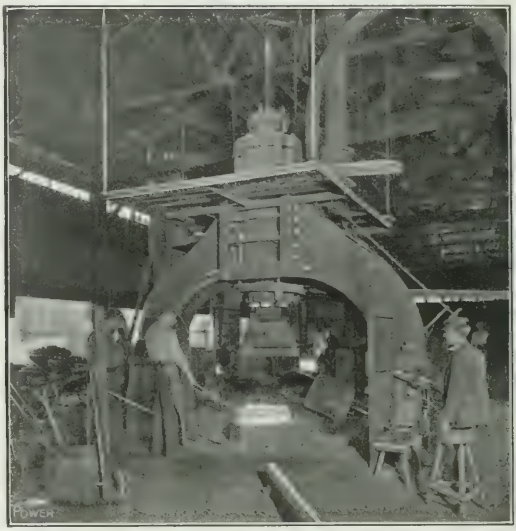


FIG. 2. PLACING LOUP UNDER HAMMER

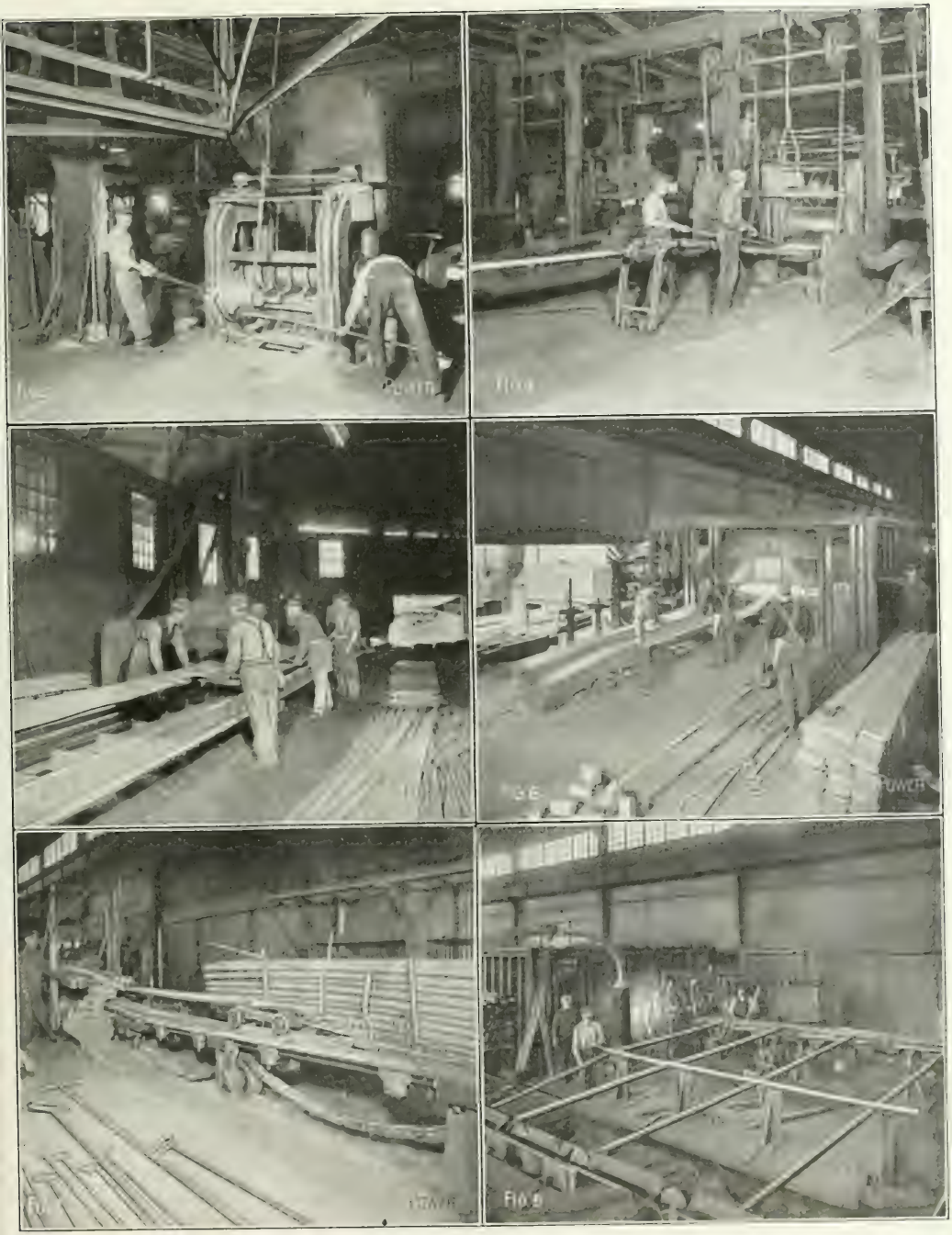


Fig. 3. Running Bloom through Rolls
Fig. 5. Trimming Plate with Rotary Shears
Fig. 7. Forming Tube from Skelp

Fig. 4. Two-High Plate Rolls
Fig. 6. Inserting Plate in Furnace
Fig. 8. Welding Process

imperative. The sulphur and silica in coke would in the first case sulphurize the iron; in the latter it would make a silicious or acid cinder with no dephosphorizing power. Charcoal from hard wood, such as maple or hickory, requires a stronger blast and works faster than that from pine or poplar.

Although the production of iron is increasing in England today for employment in bridgework, its main use in America is confined to iron roofing and charcoal-iron boiler tubes.

For boiler tubes, charcoal iron is eminently suited. It is of a fibrous nature, and will not crystallize under shock or vibration; it is ductile, can be beaded easily and securely, and requires little calking; it is preëminently weldable, is noncorrosive and will not pit easily. There are many reasons advanced to account for its noncorrodibility. One is that the intimately mixed network of cinder forms a protective covering, and under acid conditions, cinder being very little affected, this ingredient undoubtedly preserves the life of iron. Another theory ascribes this quality to its homogeneous nature, purity and low manganese, which tend to prevent electrolysis.

Production of Boiler Tubes

The accompanying illustrations show the principal steps involved in the manufacture of charcoal-iron boiler tubes as carried out at the plant of the Parkesburg Iron Co. Incidentally it may be mentioned that it takes about three carloads of charcoal to make 50 tons of charcoal iron.

Fig. 1 is a view of the knobbling fire into which the steel scrap is placed on a bed of charcoal. The furnace consists of four cast-iron plates arranged rectangularly with a tuyere entering upon one side and having a blast pressure of 1½ lb. The plastic metal is worked into a ball or loup which is lifted above the charcoal and is carried to the hammer (Fig. 2) under which much of the cinder is eliminated, the slag on the outside is knocked off and the loup formed into a bloom.

From the hammer the bloom is taken to the rolls (Fig. 3) where in three passes it is run into a bar. These bars are cut to length to make a pile of the proper weight and the piles are heated in a draft furnace. The best practice at this stage of the process is to employ an old-fashioned draft furnace, as a blast furnace is liable to blow dust in between the bars and make blisters.

Fig. 4 is a view of the plate rolls where at a welding heat the pile of bars is given several lateral passes to secure the proper width and cross-fiber. It is then rolled lengthwise to the gage desired.

After cooling, the plates are marked to the proper size and are then run through rotary shears where the skelp is cut to the proper width. This operation is shown in Fig. 5. This skelp is then carefully inspected and any strip that is found defective is not sent to the tube mill.

After being inspected, the strips of skelp are put into the bending furnace (Fig. 6), heated to a red heat and drawn cut through a door into the scarfing rolls located at the end of the furnace. The strips go through the rolls, which have a bevel at each edge to give the scarf to the skelp; and are then drawn through dies which form them into cylindrical shapes with the scarfed edges overlapping. Fig. 7 shows a tube going through the dies.

The next step in the process is welding the scarfed edges of the bent skelp. Fo this purpose the skelp is introduced in a furnace where it is raised to a weldin heat. It is then pushed out of the fu nace and into the welding rolls show in Fig. 8. There is a ball on the en of the rod which is placed between th two concave surfaces of the rolls and th pressure exerted on the bent skelp as goes through the rolls is sufficient secure a weld. The tube is given tw welding heats and goes through the wel ing rolls twice to insure a weld.

After this the tube is passed throug size-rolls which give it a true cylindric form. Passing then to the cross rol the tube is straightened and the scale knocked off, after which it goes throug a trough and is finally transferred to th cooling rack. This rack is operated different speeds, depending upon th sizes of the tubes so as to secure th proper heat treatment in cooling.

The tube next goes through a straigh ening press (a supplementary process the cross rolls) in order to insure being absolutely straight. Then after rigid inspection the ends of the tubes a sawed off to give them the proper leng and these ends are tested for crushi in a press. This operation is shown Fig. 9. An imperfect weld will be detect by this means and the tube from whi the end has been sawed is scrapped.

If the tube passes this test the en are reamed and the burrs from the sa are taken off. As this may make the tu a little thinner at the ends, another i spection is made in which the ends a gaged and the surfaces carefully look over.

The tubes now have to undergo hydrostatic pressure test of 500 lb. p square inch and in some cases 1000

Fig. 9. Testing Tube Ends

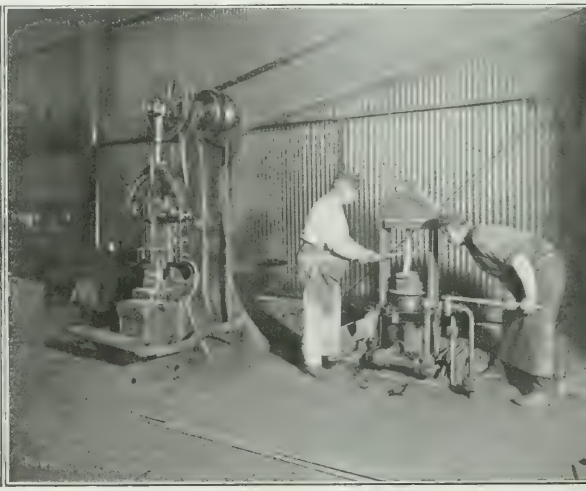


Fig. 10. Expansion Test

As an additional precaution, the tubes are tested for expansion. This consists, as shown in Fig. 10, of placing one of the sawed-off ends into a 50-ton press. A conical pin is inserted in one end and the pressure applied until the tube has expanded to 1⅛ times its original diameter without showing any signs of rupture. Furthermore, the ends are beaded to make sure that the metal is ductile. In addition to these physical tests the raw material is subjected to a chemical analysis before going to the forge fire.

For some classes of service such as with locomotives, some railroads require that the ends of the tubes have a different gage from that of the bodies. In such a case the safe-end is ¼ in. larger in diameter than the body of the tube. This is pushed over the end of the tube, brought to a welding heat in a safe-ending furnace and then drawn down under a hammer to the exact diameter of the tube.

Acton Corliss Balanced Stop Valve

There are various types of automatic stop valves used on steam-engine and boiler connections, one of which is a balanced Corliss valve, manufactured by John Acton, 118 John St., Brooklyn, N. Y. It is illustrated in detail in Fig. 1.

There are several methods of arranging this valve to operate either by hand or automatically. One installation is in the engine room of the Chelsea Fibre Mills, Greenpoint, N. Y., the arrangement for controlling the action of the valve having been worked out by Chief Engineer Leak. The valve is located in the horizontal steam line just inside the wall between the boiler and the engine steel stud and in the other an extension rod. A boss is cast on the valve bonnet which carries a dog *C*, pivoted at *D*. The dog is held in a position to engage the stud by a spring *F*, Fig. 1, which is attached to a projection on the dog. A cord is also run to the weight *G*, with extensions dropping to within the reach of the operator.

The angle lever *H* works in bracket bearings and is connected to the lever *A* by a rod. The weight *J* and dashpot have been removed. The valve stem is cut to a suitable length and operates a relay arm which is pivoted at *K*, the bottom end of the arm being fitted with a platinum contact point. The two contact blocks are connected to the relay coil *L*, which, in operating, closes the 110-volt circuit to the magnet *M*. The magnetism set up in the coil draws the armature away from the weight *G* which on becoming disengaged drops, breaking the circuit at the contact *O*.

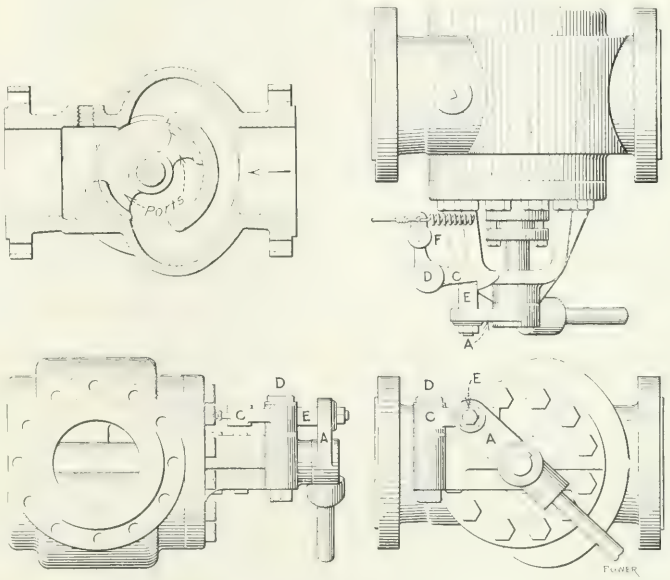


FIG. 1. ACTON BALANCED CORLISS STOP VALVE

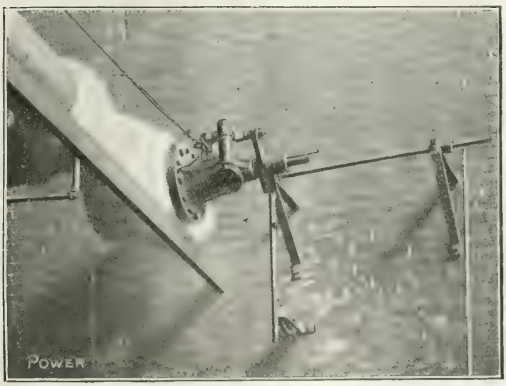


FIG. 2. VALVE OPEN

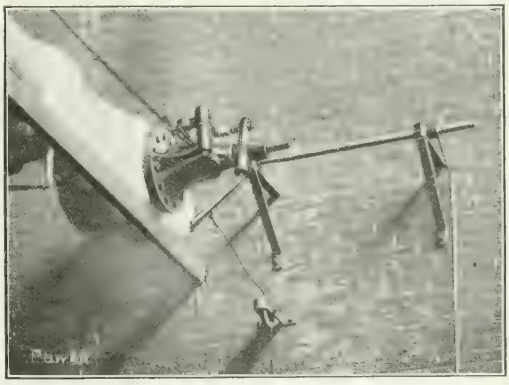


FIG. 3. VALVE CLOSED

rooms, as shown in Figs. 2 and 3, and controls both of the main engines which are of 1000 and 1200 hp. capacity.

The valve stem is fitted with a lever *A*, Fig. 4, in one end of which is a square plunger are suspended from the short end of the angle lever by an iron rod.

Each engine drives a speed-limit device consisting of a small throttling governor, the valve disk and seat of which

The speed-limit governor is speeded five to one; that is, for each increased revolution in engine speed, the governor speed increases five revolutions. As the rim of the driving wheel travels 5800

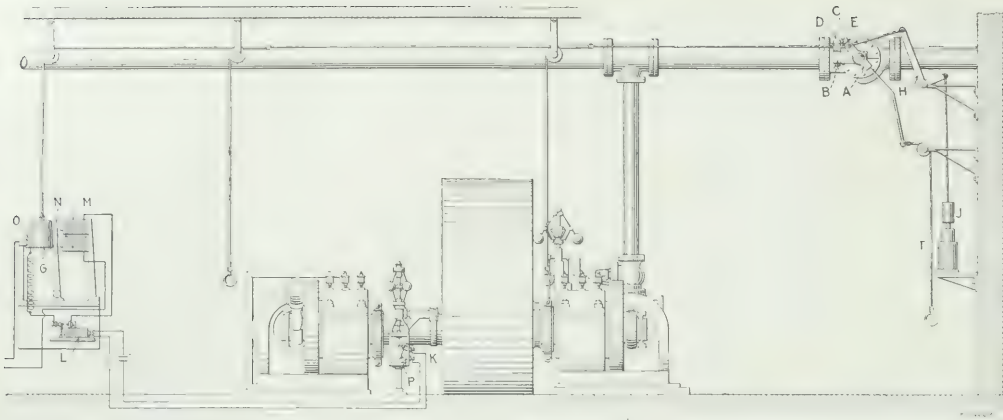


FIG. 4. ELEVATION OF VALVE AND AUTOMATIC STOP ARRANGEMENT APPLIED TO AN ENGINE AND PIPE LINE

ft. per minute, Engineer Leak has adjusted the governor so that with an increase of three revolutions of the engine above normal, the governor closes the circuit at *P* and steam is shut off from both engines by the automatic stop valve.

When the weight *G* falls, it pulls the dog *C* away from the catch block *E*. This releases the valve stem and the weight *J* pulls the valve forward. The dashpot below the weight *J* is to prevent the valve from closing with a slam.

The stop valve is closed in the same way when any one of the hand ropes is pulled, releasing the dog from the catch block.

After the valve has operated it is set in an open position by pulling down on the rope *R*, which moves the lever toward the right and latches the catch block with the dog *C*.

Before the governor acts a second time, the weight *G* must be reset on the armature *N*, which movement also closes the 110-volt circuit at the contact *O*. The device is then ready for service should the engine again exceed the normal speed limit.

Circulation Test of Robb-Brady Scotch Boiler

The claims for positive circulation made by the builders of this boiler were thoroughly tested recently at the sewage pumping station, Framingham, Mass. The Robb-Brady boiler at this plant was equipped with thermometer oil wells so that the temperature could be noted at four points: at the top of the shell near the front end, at the top of the shell, at the rear just over the combustion chamber, at the front and rear close to the bottom, as shown in Fig. 1.

With water in the boiler at about 80 deg. F., the fires were started and readings of all thermometers taken every

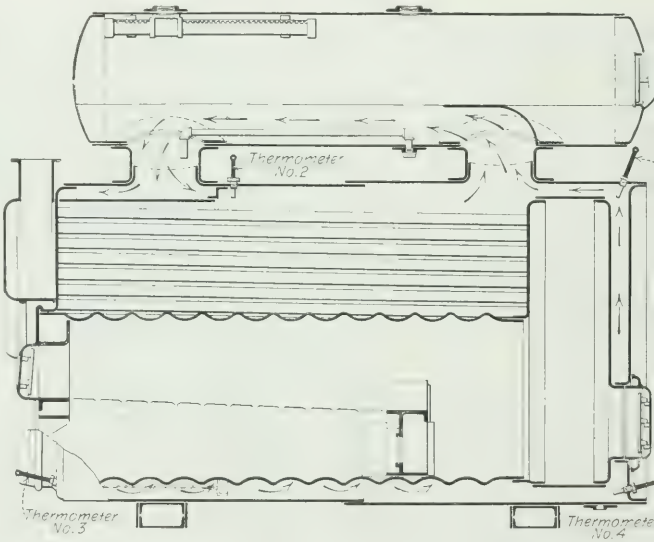


FIG. 1. BOILER SHOWING THE LOCATION OF THE FOUR THERMOMETERS

TEMPERATURE TEST, 50-HP. ROBB-BRADY SCOTCH BOILER, MARCH 31, 1912
Framingham Sewage Pumping Station, Framingham, Mass.

Time P.M.	Thermometer No. 1 On Top of Boiler at Rear End, Deg. F.	Thermometer No. 2 On Top of Boiler at Front End, Deg. F.	Thermometer No. 3 At Bottom of Boiler at Front End, Deg. F.	Thermometer No. At Bottom of Boil at Rear End, Deg.
3:40	114	112	80	82
3:45	126	124	80	82
3:50	138	140	80	83
3:55	150	150	81	84
4:00	170	170	82	86
4:05	194	190	84	87
4:10	210	210	98	90
4:15	226	224	210	136
4:20	231	230	226	180
4:25	244	242	234	230
4:30	258	260	252	248
4:35	276	278	268	270
4:40	292	292	292	290
4:45	310	308	306	310
4:50	328	330	328	328
Safety Valve Blowing off				
4:55	330	330	328	330
5:00	327	328	327	327

five minutes. As was expected, the temperature of the water at the top of the shell increased steadily until the boiling point was reached. At the bottom, the temperature increased very slowly up to the time the upper thermometer indicated the boiling point. Then the lower thermometers showed a sudden rise, jumping to within a few degrees of those

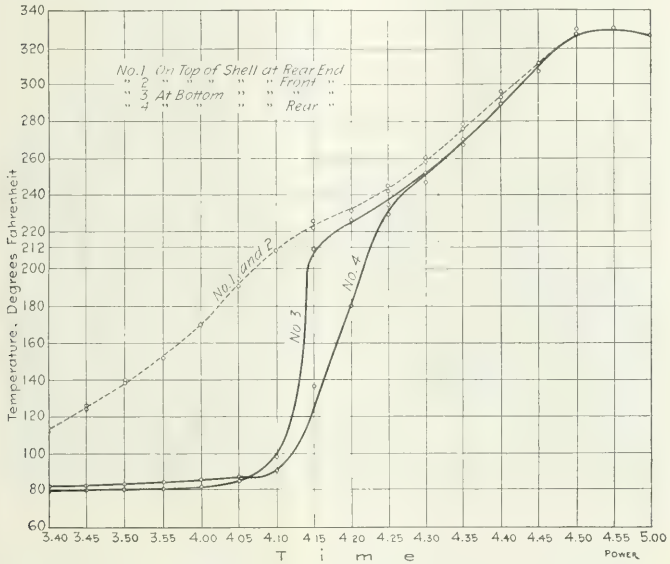


FIG. 2. CURVES OF THERMOMETER READINGS

at the top. From this time on all four kept within a few degrees until 100 lb. pressure was reached, when practically no difference could be noted at the four points, showing conclusively that the circulation was positive and rapid. The accompanying curve, Fig. 2, gives graphically the thermometer readings at five-minute intervals. The table gives the readings of the four thermometers during the test. A description of this boiler appeared in POWER, July 11, 1911, page 76.

The test was witnessed by many prominent consulting and operating engineers and the representatives of several boiler-insurance companies.

Old Sawmill Boiler Explodes

On May 18, a boiler of the locomotive type with a 30-hp. engine mounted on top, exploded in the sawmill of John de Frain, East Vincent, Chester County, Penn. Two men were killed and three injured and a property damage amounting to about $1000 resulted.

The boiler, which was 31 years old, was 10 ft. long and contained sixty-five 2-in. tubes. The joints were single-riveted, pitch 2 in. The working pressure was 65 to 75 lb. and the safety valve was set at 80 lb.

The boiler, minus the furnace, was blown endwise out of the building, demolishing the roof entirely and landing 50 yd. away. Eighteen of the tubes were strewn along the path taken by the boiler. Two weeks previous a boiler maker inspected the boiler and claimed that it was in excellent condition. Just before the accident the water glass showed that the boiler contained 2½ gages of water so that it is necessary to look elsewhere for the cause of the explosion.

Apparently the initial rupture occurred in the crown-sheet. This was found to be less than ⅜ in. thick and a bad lamination showed up in the plate.

At the coroner's inquest it was brought out in the evidence that the crown-sheet was badly rusted on both sides. A piece of metal was produced which had been twisted out from the sheet with the fingers of the man giving the testimony. It was in bad condition and had been taken from a point very near the safety plug which was still in perfect order.

The boiler-feed water was drawn from a spring and there was no evidence of scale or oil having found its way to the surface of the sheets. A gradual deterioration during the 30 years of service had probably weakened the crown-sheet to the point of failure which occurred when blowing down the boiler.

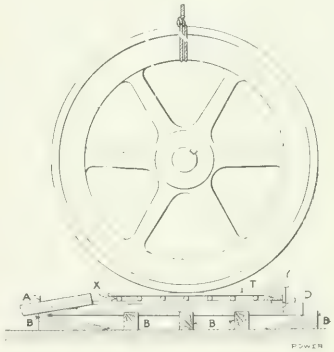
BOILER MINUS FURNACE SEVERAL HUNDRED FEET FROM SETTING

Removing a Heavy Flywheel

BY L. S. DURMON

While operating as night engineer in a small electric-light and power plant, located in an isolated and sandy part of South Dakota, the writer experienced trouble with a hot main bearing on one of the engines.

The engines were of the internal-combustion, two-stroke-cycle type, and it was undoubtedly the suction of the intake that drew sand into the engine, where it finally found its way to the bearing, causing it to heat. After running about an hour the bearing became so hot that it was necessary to shut down the engine. The bushing was of the usual cylindrical form and slipped on over the shaft, to remove which it was necessary to remove the flywheel. I was alone, with no telephone to summon aid, but as the plant furnished 24-hr. service, something had to be done; I decided to do the job single-handed.



SHOWING METHOD OF BLOCKING THE WHEEL

Some pieces of sheet iron about 3 ft. square and ⅜ in. thick, some ball bearings, a short piece of rope, a number of planks and blocks, and a crowbar completed the outfit for the removal of the flywheel.

The wedges *B* in the accompanying illustration were made of oak. The plank

D was placed under the wheel and one of the plates laid upon it. On top of the plate the balls *X* were placed, and on top of these was laid the plate *T*. The wedges were then driven in until the plates took the weight of the wheel. The key was then withdrawn and the wheel worked back and forth until it came off the shaft. A short piece of rope was fastened to the top of the wheel to prevent it from tipping over.

After the wheel was taken off the shaft the lag screw and block *Y* were placed in position to prevent the wheel from rolling backward when it was being rolled on the plank *A*. The bushing was then removed and put back on the shaft in a reverse position, after which the wheel was rolled up the plank with a crowbar and replaced on the shaft. The job required about five hours to complete, but, considering the condition, the time was really short.

American Type of Uniflow Steam Engine

In 1872 an American patent was granted on an improvement in reciprocating steam engines consisting of an opening through the bottom of the cylinder wall at or near the middle of its length. Toward the end of its stroke the piston uncovered the opening, allowing the water and the steam not exhausted through the valve-controlled port at the top of the cylinder to discharge at the bottom. This seems to have been the forerunner of the uniflow design, although the inventor did not realize the advantages of widely separating the admission and exhaust valves, or he would have omitted the other and used the central exhaust port entirely.

Years later, L. J. Todd evidently recognized the value of the uniflow principle. He developed a design based on it and in 1886 took out English patents. Apparently Mr. Todd did not push the practical application of this principle to any great extent. The credit for this belongs to Prof. Stumpf, of Charlottenburg, Germany, whose engine, built on this principle, has attained commercial success. The Stumpf uniflow engine, which was fully described in POWER, Jan. 31, 1911, and mentioned in still earlier issues, is equipped with poppet valves, conforming with German practice.

The Nordberg Manufacturing Co., Milwaukee, Wis., is the pioneer in developing the uniflow principle in America. This company built a uniflow engine early in 1911 and set it up with separate surface condenser, air pump, electric generator, water rheostat and all equipment necessary for complete and accurate testing. Over 100 complete tests were made with different steam pressures, vacuums and speeds. Corliss valves were adopted as more in accord with American practice and familiar to practically all operating engineers. The gear used was specially designed for this engine's speed and service requirements.

The uniflow engine derives its economy through largely reducing the loss due to initial condensation. In a four-valve cylinder one face of the piston and the corresponding cylinder head are exposed to the exhaust temperature almost throughout each stroke, or 90 per cent. or more of the time. The admitted steam meeting these large cooler surfaces is partly condensed, and while some may be reëvaporated toward the end of the stroke, there is still a considerable heat loss.

each stroke, so that in effect the piston is the exhaust valve. The two steam valves *A* are in the cylinder heads, and the steam spaces over the valves with the clearance pockets *B* completely steam-jacket the heads.

Unlike the four-valve engine, the uniflow engine's piston faces and cylinder heads are exposed to exhaust temperature only the short time the piston uncovers and again covers the exhaust ports. On the return stroke the steam remaining in the cylinder is compressed in the clearance space up to admission pressure. The temperature also increases

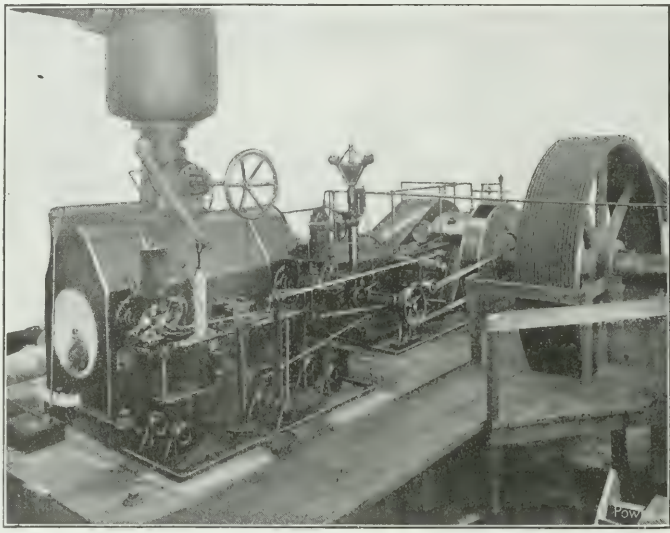


FIG. 1 EXPERIMENTAL ENGINE ON TESTING BED

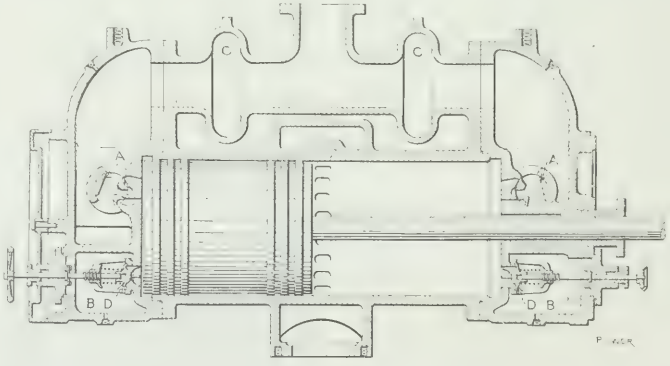


FIG. 2. SECTION THROUGH CYLINDERS OF THE NORDBERG UNIFLOW ENGINE

A view of the valve-gear side of the experimental uniflow engine on the testing floor is given in Fig. 1. Fig. 2 shows a section through the cylinder. This cylinder has no exhaust valves, but in its middle is a ring of ports which are uncovered by the piston at the end of

not only due to the compression but also to absorption of heat from the head jacket until it is considerably higher than that of the admitted steam.

The cylinder, Fig. 2, is a simple cylindrical casting with a belt cast in the middle for the exhaust passage. The steam

chest is integral with the cylinder and provided with two drums *C* to take up expansion without distorting the cylinder.

Each end of the cylinder has a large valve *D* opening into a pocket *B* in the

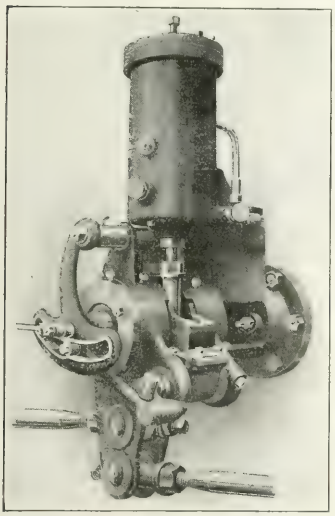


FIG. 3. VALVE MECHANISM

cylinder head. Opening automatically, these serve both as large relief valves to let out entrained water and extra clearance to prevent excessive compression if the vacuum is lost when running condensing. If the engine is to run continuously noncondensing, the valves may be held from their seats to increase the clearance by the volume of the pocket.

the actual feet of travel which determines the wear are no greater with these valves when running at 150 r.p.m. than with single-ported Corliss engine valves running at half the speed.

The valve mechanism, Fig. 3; is especially designed for high speed and hard service. Unlike the standard Corliss gear, the steam arm is not supported on the valve stem, but on a large bearing extended from the steam bonnet. This arm has two bearings for the hook, one on each side of a central plane with respect to which the entire gear is symmetrical, and there are no overhung parts or side strains. The steel trip blocks are exceptionally wide and the dashpots are of the spring type to insure positive action at high speed. The valve stems have two bearings in the bonnets. The cutoff gear gives any point of cutoff from zero to eight-tenths stroke under full control of the governor without distorting the valve motion, so that positive lap is retained and the valves open at maximum speed.

Figs. 4 and 5 show typical indicator diagrams and Figs. 6 and 7 the economy attained by this engine under 150 lb. initial pressure and ½ lb. back pressure, running noncondensing and under 160 lb. initial pressure and 26 in. of vacuum running condensing. The speed was 150 r.p.m.

This engine is remarkable for its great overload capacity and its flat steam-consumption curve. Fig. 7 shows that the engine will take an overload of 100 per cent. with an increase in steam consumption per horsepower-hour of about 10 per cent.

The engine is particularly adapted to

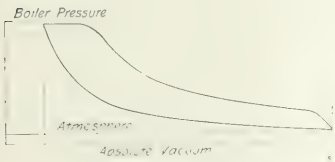


FIG. 4. NONCONDENSING DIAGRAM

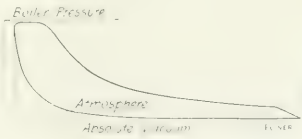


FIG. 5. CONDENSING DIAGRAM

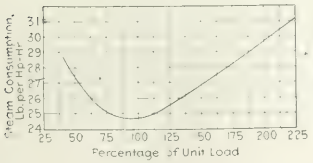


FIG. 6. NONCONDENSING ECONOMY CURVE

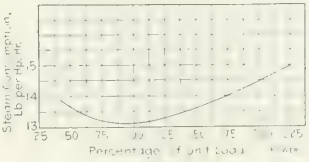


FIG. 7. CONDENSING ECONOMY CURVE

The piston is of the block type and is provided with three snap rings at each end. The Nordberg patent four-ported steam valves give a large opening with a small movement of the valve so that

rolling-mill service, street-railway and lighting work and general power purposes where the load is subject to wide fluctuations; that is, where the load factor is low.

Economy Tests of Steam Turbines

The table herewith is part of a paper on the "Present State of Development of Large Steam Turbines," read at the spring meeting of the American Society of Mechanical Engineers by Prof. A. G. Christie, of the University of Wisconsin. With regard to this phase of the subject he says:

The efficiency of a steam turbine may be expressed in terms of pounds of steam per kilowatt-hour, as an efficiency ratio or as the B.t.u. required per kilowatt-hour.

The steam consumption is dependent on the initial steam pressure, its temperature or quality, and the condenser pressure. These factors vary in almost every test and the effect of a variation in each is not the same for all classes of turbines. Hence, different turbines cannot usually be compared satisfactorily on the basis of their steam consumption alone.

If the steam could expand freely to exhaust pressure in a turbine without radiation, friction, eddy or windage losses, its expansion would be adiabatic and on the Rankine cycle. The "efficiency ratio" expresses the proportion of the heat actually turned into work to that available from such an adiabatic expansion; in other words, it expresses the efficiency of the actual turbine as compared to the ideal turbine, and is independent of the type of turbine.

The B.t.u. per kilowatt-hour is figured above the heat of the liquid at exhaust pressure. This is not a satisfactory standard by which to compare results, for it is largely dependent on conditions beyond the control of the turbine builder. For instance, if the plant does not contain superheaters, the B.t.u. per kilowatt-hour will be high. The same will be true of a plant which has a warm cooling-water supply for condensers and consequently carries low vacuum. Yet the turbines may be designed to give a high efficiency ratio under these conditions. In fact, they may be able to utilize the heat available more efficiently than the turbines in another plant with both high superheat and high vacuum.

This can be seen in the accompanying tabulation of recent turbine results. The Brown-Boveri turbine at the Dunstan power plant uses 14,980 B.t.u. per kilowatt-hour with an efficiency ratio of 68.8 per cent. Yet the Westinghouse City Electric, with a lower steam pressure, superheat and vacuum, has an efficiency ratio of 68.9 per cent., though using 16,925 B.t.u. per kilowatt-hour. The Erste Brünner Vienna turbine requires 16,460 B.t.u. per kilowatt-hour with 71.8 per cent. efficiency ratio. It is therefore apparent that the efficiency ratio alone will express in the best manner the de-

gree to which the designer has approached ideal results in his turbine.

The test results in the table were grouped in order to analyze the relative merits of the different types of turbines on the basis of efficiency ratios. The Curtis-Parsons machines built by Erste Brünner hold first place in the list, but are followed closely by others of the same type built by Brown-Boveri and Westinghouse Machine Co. The Parsons turbines built by Allis-Chalmers and Brown-Boveri also show high efficiencies. The second class in the order of efficiency includes turbines of the Curtis-Rateau and Curtis-Zoelly types, among which the turbines of the A. E. G. and British Westinghouse Co. show remarkably good results. The next group includes simple Zoelly and Rateau turbines. The last group comprises straight Curtis types.

The superiority of the Curtis-Parsons over the Parsons type is probably due to the reduction in the fluid friction and rotational losses occurring in the first cylinder of the Parsons by the use of a Curtis stage in this section.

The Parsons low-pressure sections evidently utilize the heat in the steam only slightly more efficiently than do the impulse turbines. The great surface areas of all disk-type turbines which must be whirled in steam, produce losses which are apparently somewhat larger than the combined whirling losses and leakage in the Parsons drum turbines. Both the Zoelly and Curtis-Rateau types appear to use the steam more effectively in the low-pressure sections than the Curtis alone. Many European engineers hold the opinion that where high economy is to be obtained, the impulse turbine of the Rateau or Zoelly type is superior to the Curtis, though its manufacturing costs are higher. The Curtis-Rateau construction has all the commendable features of impulse turbines and has proved very economical.

The results in the table are from the best reliable tests that have been made on each type. Objections may be raised that these results do not represent actual operating conditions as under varying loads, nor the average economy of any type of turbine. For instance, the Curtis turbine usually gives a very flat water-rate curve, while the Parsons type is more convex. On the other hand, recent tests on the new Curtis-Parsons types have also shown flat water-rate curves at various loads. It was impossible to compare the various types from this standpoint on account of absence of complete data of such tests.

It is interesting to note that the best results have been obtained within the past two years and that these show a considerable increase in efficiency over the earlier turbines.

ECONOMY TESTS OF HIGH PRESSURE STEAM TURBINES
Efficiency Ratios Based on E.H.P. Marks & Davis Steam Tables Used

Maker of Turbine	Type	Date of Test	Load-Kw	R.p.m.	Steam Pressure, Lb Absolute	Temperature at Throttle, Deg. F.	Vacuum Referred to 29.92" Bar.	Condenser Pressure, Lb Absolute	Lb. of Steam per Kw.-hr.	B.t.u. per Kw.-hr	Heat Utilized per Lb. of Steam	Heat Available per Lb. of Steam	Efficiency Ratio	Reference
Erste Brünner M. F. G.	Curtis-Parsons	1910	2,128	1500	156.2	482	27.89	0.995	13.82	16,460	247.0	343.8	71.8	*Periodische Mitteilungen*
Erste Brünner M. F. G.	Curtis-Parsons		6,000	960	184.9	573	28.18	0.854	12.56	15,570	271.5	380.7	71.3	*Zeit. D.V.D. Ing.*, 12/10/'10
Erste Brünner M. F. G.	Curtis-Parsons	1910	7,442	960	192.0	584	28.18	0.853	12.625	15,705	270.2	384.4	70.3	*Periodische Mitteilungen*
Westinghouse Machine Co.	Curtis-Parsons	1910	9,173	1800	181.7	433	27.81	1.032	14.57	16,925	234.1	340.2	68.9	*Trans. A.S.M.E.*, vol. 32
Brown-Boveri & Cie	Curtis-Parsons		3,053	1360	150.2	505	29.00	0.456	13.01	15,990	262.2	385.5	68.0	*Dinglers P.J.*, 6/17/'11
Erste Brünner M. F. G.	Curtis-Parsons	1910	1,416	1260	128.2	482	27.60	1.137	15.18	18,060	224.6	326.5	68.8	*Periodische Mitteilungen*
Brown-Boveri & Cie	Curtis-Parsons	1911	1,750	1500	176.4	586	27.08	1.392	14.23	17,500	239.5	354.8	67.5	*Zeit. F.D.G. Turb.*, 5/30/'11
Brown-Boveri & Cie	Curtis-Parsons	1910	3,764	1500	161.2	561	28.77	0.562	13.04	16,290	261.5	391.4	66.8	*Zeit. F.D.G. Turb.*, 5/30/'11
Westinghouse Machine Co.	Curtis-Parsons		9,830	750	192.2	475	27.22	1.322	15.15	17,790	225.2	336.0	67.0	*Trans. A.S.M.E.*, vol. 32
Brown-Boveri & Cie	Curtis-Parsons	1911	1,495	3000	200.6	563	26.41	1.720	14.78	17,880	230.7	345.5	66.8	*Data from Manufacturer*
Brown-Boveri & Cie	Curtis-Parsons	1911	1,271	3000	172.1	568	27.31	1.278	14.61	17,880	233.5	354.3	65.9	*Data from Manufacturer*
Westinghouse Machine Co.	Curtis-Parsons	...	11,466	750	191.2	441	28.07	0.910	14.45	17,210	236.0	360.5	65.5	*Trans. A.S.M.E.*, vol. 32
Erste Brünner M. F. G.	Curtis-Parsons		1,250	3000	184.9	573	27.89	0.996	14.32	17,680	238.2	373.1	63.9	*Zeit. D.V.D. Ing.*, 12/10/'10
Brown-Boveri & Cie	Curtis-Parsons	1910	3,320	1500	180.9	525	29.02	0.440	13.50	16,680	252.7	401.3	63.0	*Zeit. F.D.G. Turb.*, 5/30/'11
Brown-Boveri & Cie	Curtis-Parsons		5,128	1000	171.2	565	28.52	0.726	14.35	17,830	237.7	382.9	62.1	*Stodola, 4th ed.*, p. 449
Breitfield, Danek & Co.	Impulse Parsons	1909	3,585	896	160.7	457	28.32	0.782	16.08	19,070	212.0	352.4	60.2	*Zeit. D.V.D. Ing.*, 12/10/'10
Brown-Boveri & Cie	Parsons	1910	6,257	1210	203.7	559	29.02	0.440	11.95	14,980	285.5	415.0	68.8	*Official Test Report*
Allis-Chalmers	Parsons	1908	4,300	1800	186.4	484	27.96	0.960	14.02	16,690	243.4	355.7	68.4	*Sibley Jour. of Eng.*, 1/'11
Brown-Boveri & Cie	Parsons	1903	3,500	1360	156.4	499	28.84	0.532	13.71	16,720	248.5	378.6	65.6	*Zeit. D.V.D. Ing.*, 12/10/'10
Brown-Boveri & Cie	Parsons		3,000	1360	165.0	625	27.02	1.420	14.75	18,433	231.3	359.5	64.3	*Die Turbine*, 6/20/'11
C. A. Parsons & Co.	Parsons	...	5,164	1200	214.3	509	28.95	0.473	13.18	16,140	258.7	402.3	64.3	*Stodola, 4th ed.*, p. 439
Allis-Chalmers	Parsons	1911	3,850	1800	164.7	491	27.91	0.983	15.40	18,410	221.3	348.3	63.5	*Power*, 1/2/'12
A. E. G.	Curtis-Rateau	1911	6,518	1220	198.7	601	29.28	0.352	11.43	14,640	298.4	434.2	68.7	*Official Test Report*
A. E. G.	Curtis-Rateau	1911	6,565	1220	200.1	597	29.18	0.406	11.64	14,848	293.0	427.7	68.5	*Official Test Report*
British Westinghouse	Curtis-Rateau	1911	5,066	1500	190.2	552	28.68	0.649	13.00	16,100	262.4	391.5	67.0	*Electrical Review*, 6/23/'11
M. A. N.	Curtis-Zoelly		3,584	1500	178.3	569	27.54	1.166	13.99	17,190	243.7	361.3	67.5	*Data from Manufacturer*
Bergmann	Curtis-Rateau	1909	1,545	1500	188.5	581	28.59	0.654	12.97	16,230	263.0	396.3	66.4	*Zeit. D.V.D. Ing.*, 12/10/'10
Bergmann	Curtis-Rateau	1910	2,477	1500	140.0	522	28.81	0.588	13.93	17,135	244.8	373.4	65.6	*Elec. Zeit.*, 4/20/'11
A. E. G.	Curtis-Rateau	1908	4,239	1500	188.3	662	29.11	0.397	11.97	15,620	284.9	439.0	64.9	*Stodola, 4th ed.*, p. 404
British Westinghouse	Curtis-Rateau	1911	2,930	1500	210.2	568	28.18	0.894	13.72	16,935	248.7	383.3	64.9	*Electrical Review*, 4/28/'11
A. E. G.	Curtis-Rateau	1907	3,163	1500	191.7	592	29.37	0.397	12.74	16,230	267.7	425.1	63.0	*Trans. A.S.M.E.*, vol 32
M. A. N.	Curtis-Zoelly		2,507	1500	175.5	460	27.40	1.234	16.24	19,020	210.0	334.6	62.8	*Data from Manufacturer*
Bergmann	Curtis-Rateau	1909	1,562	1500	186.8	555	28.33	0.780	14.57	17,970	234.1	381.3	61.4	*Data from Manufacturer*
James Howden & Son	Zoelly	1909	6,383	1000	202.7	520	27.33	1.269	14.305	17,150	238.5	353.0	67.5	*Engineer, London*, 10/29/'09
M. A. N.	Zoelly	1910	1,400	3000	180.7	554	27.40	1.237	14.21	17,310	240.0	356.2	67.4	*Zeit. D.V.D. Ing.*, 12/10/'10
Escher, Wyss & Co.	Zoelly	1910	2,052	3000	193.9	585	28.39	0.750	13.04	16,290	261.5	392.6	66.6	*Zeit. F.D.G. Turb.*, 2/20/'11
Escher, Wyss & Co.	Zoelly	1910	4,180	1000	179.7	557	28.66	0.618	13.30	16,520	256.5	391.3	65.5	*Zeit. F.D.G. Turb.*, 2/20/'11
F. Ringhoffer	Zoelly	1908	3,000	1000	170.7	470	27.60	1.138	15.52	18,278	219.8	339.2	64.8	*Zeit. D.V.D. Ing.*, 12/10/'10
M. A. N.	Zoelly	1910	1,250	3000	182.1	582	28.82	0.540	13.09	16,500	260.2	404.5	64.4	*Zeit. D.V.D. Ing.*, 12/10/'10
Oerlikon	Rateau	1911	3,166	1500	213.9	663	29.25	0.367	11.44	14,970	298.2	450.6	66.1	*Engineering*, 10/20/'10
Escher, Wyss & Co.	Zoelly	...	5,118	1000	133.7	549	27.55	1.161	15.18	18,530	224.6	341.6	65.7	*Dinglers P.J.*, 7/15/'11
Escher, Wyss & Co.	Zoelly	1908	5,000	1000	166.4	539	26.38	1.736	16.13	19,350	211.2	330.4	63.9	*Zeit. D.V.D. Ing.*, 12/10/'10
Escher, Wyss & Co.	Zoelly	...	3,540	1500	155.1	469	28.21	0.838	15.07	17,940	226.3	349.5	64.8	*Dinglers P.J.*, 7/15/'11
Escher, Wyss & Co.	Zoelly	1910	1,641	3000	221.0	672	27.91	0.985	13.08	16,773	260.6	406.5	64.1	*Zeit. F.D.G. Turb.*, 2/20/'11
Escher, Wyss & Co.	Zoelly	1910	1,235	3000	176.8	454	28.39	0.750	15.35	18,156	222.3	357.8	62.2	*Zeit. F.D.G. Turb.*, 2/20/'11
British Thomson-Houston	Curtis	1911	2,987	1500	154.7	505	26.75	1.557	15.96	18,960	213.7	321.2	66.5	*Engineering*, 10/20/'11
Gen. Elec. Co.	Curtis		3,464		210.0	513	28.75	0.575	13.62	16,620	250.4	393.4	63.6	*Trans. A.S.M.E.*, vol. 32
British Thomson-Houston	Curtis	1909	2,500	1500	126.5	414	28.47	0.711	15.92	18,590	214.0	336.1	63.7	*Zeit. D.V.D. Ing.*, 12/10/'10
A. E. G.	Curtis	1906	3,000	1500	191.3	590	29.05	0.427	12.79	16,240	266.6	420.4	63.4	*Zeit. D.V.D. Ing.*, 12/10/'10
A. E. G.	Curtis	1909	2,236	1500	191.6	654	29.34	0.284	11.77	15,450	289.8	455.8	63.6	*Zeit. D.V.D. Ing.*, 12/10/'10
Gen. Elec. Co.	Curtis		8,880		192.5	487	29.02	0.933	15.75	17,965	226.7	359.5	63.1	*Trans. A.S.M.E.*, vol. 32
British Thomson-Houston	Curtis	1911	1,541	1500	149.7	365	27.97	0.956	17.46	19,720	195.3	320.2	61.0	*Engineering*, 10/20/'11
Gen. Elec. Co.	Curtis	...	10,816	750	190.0	525	29.39	0.260	12.90	16,135	264.5	427.3	61.9	*Trans. A.S.M.E.*, vol. 32
Gen. Elec. Co.	Curtis		5,095		185.1	554	29.40	0.255	12.71	16,090	268.4	436.0	61.6	*Trans. A.S.M.E.*, vol. 32
British Thomson-Houston	Curtis	1911	1,221	3000	134.7	448	27.16	1.353	17.75	20,690	192.2	314.0	61.2	*Engineering*, 10/20/'11
Gen. Elec. Co.	Curtis	1910	8,775	750	194.0	451	27.95	0.956	15.95	18,720	213.8	350.8	61.0	*Trans. A.S.M.E.*, vol. 32

References: *Zeit. D.V.D. Ing.*—Zeitschrift des Vereines Deutscher Ingenieure; *Zeit. F.D.G. Turb.*—Zeitschrift fur das Gesamte Turbinenwesen; *Dinglers P.J.*—Dinglers Polytechnisches Journal; *Elec. Zeit.*—Electrotechnische Zeitschrift.

CO_2 Recorders

By A. Vincent Clarke

Some of the reasons given by engineers for not adopting the CO_2 recorder, or making a practice of analyzing the flue gases in their plants, have been pointed out in Power. The principal reasons appear to be that many engineers do not feel that they possess sufficient knowledge of chemistry to operate the apparatus, and, although a great deal has been written about the subject, the fundamental principles have not been given; consequently they have been unable to educate themselves.

Although the average engineer may be very proficient as a chemist, and hence it may be difficult to induce him to take an interest in subjects involving a knowledge of chemistry, if only he could be persuaded to take an interest he would find his profession much more interesting, and would benefit financially by his ability for cutting down working expenses.

Most engineers consider that they know what occurs in the boiler furnace during combustion, yet they do not seem to know what methods can be adopted to determine whether the maximum efficiency has been obtained. The latter knowledge should very simply follow on from the former and is in fact only the completing of the former knowledge.

It is well known that for combustion the burning coal on the grate should be supplied with oxygen, and that sufficient oxygen should be supplied so that all of the carbon in the coal can be converted into carbon dioxide (CO_2).

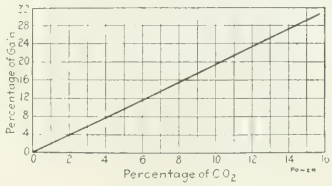
For the formation of carbon dioxide one atom of carbon unites with two atoms of oxygen or, by weight, 12 parts of carbon unite with 32 parts of oxygen, and during this formation much heat is generated. The oxygen is taken from the air which is allowed to enter through the ashpits.

If after its formation the carbon dioxide has to pass through the upper layers of the burning coal its tendency is to take up additional carbon and form carbon monoxide (CO). For the formation of carbon monoxide one atom of carbon unites with one atom of oxygen, or, by weight, 12 parts of carbon unite with 16 parts of oxygen; although it is composed of the same quantity of carbon but only half the quantity of oxygen as carbon dioxide, yet the volumes of the two gases are the same. By the conversion of one volume of carbon dioxide into two volumes of carbon monoxide heat is absorbed and the quantity of carbon taken up during this conversion is lost so far as this first process is concerned.

Carbon monoxide inflames at a comparatively low temperature, and in the furnace its combustion is secured either by the air passing in above the fire or by that which gets through the fuel bed uncombined.

Air contains four times as much nitrogen as oxygen; therefore in order to pass one volume of oxygen five volumes of air must be passed through the fire, or, by weight, 4 parts of oxygen to 18 parts of air. The nitrogen simply absorbs heat when passing through the fire and carries it to waste up the chimney, and this loss of heat cannot be remedied. If too much oxygen is allowed to pass through the fire, then this, with its accompanying nitrogen, carries so much more heat up the chimney.

Thus it is seen that if too little oxygen be supplied to the coal, then the combustion will not be complete and some proportion of the heat value of the coal will be lost, whereas if too much oxygen be supplied there will be a direct loss of heat up the chimney. Incidentally it is seen that a thin fire facilitates combustion by offering the least resistance to the passage of air through it, and so minimizing the risk of the formation of carbon monoxide; great care must be



Efficiency Increasing with CO_2

taken, however, that with this thin bed of fuel it does not burn into holes and allow air to pass through without having its oxygen consumed, thus causing a waste of heat.

The composition of the flue gases varies considerably, and the efficiency of combustion can be determined only by an analysis of these gases. By this means it may be ascertained whether there has been a loss of heat by the admission of a greater amount of air to the furnace than is necessary for effecting proper combustion, or by the admission of a smaller amount of air than is necessary, thus allowing the escape of carbon monoxide.

In a complete flue-gas analysis the most important constituents of the gases to be determined are: carbon dioxide, carbon monoxide and oxygen, the remainder of the gases being nitrogen and a small proportion of other gases originating from the coal and the air. The presence of carbon dioxide shows complete combustion, that of carbon monoxide, incomplete combustion.

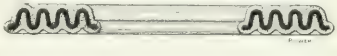
The accompanying figure shows the gain in efficiency that it is possible to obtain by increasing the percentage of carbon dioxide in the flue gases in a plant in which the percentage is as low as 5 per cent.; if this could be increased to 15 per cent., then an increase in fuel efficiency of nearly 20 per cent. would be accomplished, and it can be readily seen that this means a large saving of money.

CO_2 recorders are very essential for the attainment of the maximum efficiency of the process of combustion, but inasmuch as they give a continuous record of the percentage of carbon dioxide, they should be regarded as giving only a general indication of the efficiency for they do not give an idea of the possible losses due to incomplete combustion. Probably the best system of flue-gas analysis is one in which a continuous record of the carbon dioxide is obtained by means of a recorder and an occasional record of all of the other gases is obtained by means of the Orsat apparatus.

By means of a recorder, the stoker can detect any loss of efficiency in his furnace within two to three minutes of its occurrence; he has a guide as to the correct thickness of fire or the correct amount of draft to be given to the fire under varying conditions, and he has an indication should there be any leakage of air through the brickwork between the furnace and the position in the flue where the gas is taken from. These advantages can only be obtained by means of a recorder and its value is thus realized.

Devo Gasket

The Devo gasket is intended for high and low pressures, also for superheated steam, and consists of a corrugated steel gasket entirely embedded in an asbestos covering, which is graphited throughout. The gasket is ⅛ in. in thickness, but it can be compressed to $\frac{1}{16}$ in.



Sections through Devo Gasket

Being deeply corrugated, this gasket will make a steam-tight joint even where the flange surface is unusually rough; it is applied inside the flange-bolt holes, thus requiring a small-size gasket. It is manufactured by the Goetze Gasket & Packing Co., New Brunswick, N. J.

Burst Flywheel at Gibsonburg, Ohio

On May 24, a flywheel in the Collier sawmill at Gibsonburg, Ohio, exploded. Part of the wheel crashed through the roof of the building, landing in the mill yard. One man was injured by the force of the explosion.

According to the press reports, the accident was due to excessive rim speed.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Switchboard Connections for Testing Meters

By G. C. Cassard

In the electric-lighting business, satisfactory service depends largely upon the proper testing and maintenance of the various switchboard meters installed in the generating plant and substations. Much time is involved in this work at best, as certain types of meters require frequent attention, and it is quite important that the quickest and most convenient methods be employed consistent with safety. Of the various meters used on direct-current systems, ammeters are by far the most numerous, and for this reason the present discussion will be confined to them.

Fig. 1. Arrangement of Direct-Current Switchboard

In connection with the accompanying diagrams, the portable shunt and millivoltmeter method of testing is assumed as this is the most generally used. Fig. 1 shows a common arrangement of a direct-current switchboard (without auxiliary apparatus) when only busbar No. 1 is used during the periods of light load. This is the best time for meter testing, as it affords an opportunity to use any or all of the other three busbars for the various connections.

These diagrams may be taken to show either the positive or the negative side of the system, as both sides are handled similarly. In the arrangement under consideration there are two switches in each set, the left one engaging busbars Nos. 1 or 3, and the right one (shown open in a plane perpendicular to the page) engaging busbars Nos. 2 or 4. The switchboard meters are usually of the millivoltmeter and shunt type, like the standard, but are represented as in the diagram for the sake of simplicity.

Feeder Ammeters

Referring to the Fig. 2, it will be seen that, with the feeder under test on busbar No. 2, its load can be carried only in one way—that is, through the standard shunt, from busbar No. 1 to No. 2—therefore, this reading will appear on the standard meter and will be the lowest point of the check. The load may now be increased to any desired amount by connecting the jumper and carrying additional feeders on busbar No. 4 as indicated by the dotted line. The whole station load may thus be thrown on one meter if necessary, although that meter may be practically idle under operating conditions or be only a "spare," that is, entirely disconnected from the outside system. In making the changes shown, it is important to remember that the feeders in every case must be switched in on busbar No. 4 before pulling clear of No. 1; otherwise the feeder will be "dropped" from the switchboard.

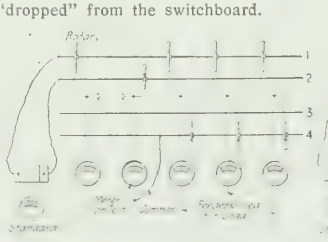


Fig. 2. Testing Feeder Meter

It is not practicable on a board of this kind to use busbar No. 3 as that would necessitate "flashing over" from No. 1 to No. 3, or tying in each time on No. 2 or No. 4.

Balancers

In the case of a balancer ammeter the connections are the same, but the scale reads in both directions from the middle, and after a check in one direction it is necessary to reverse the current. To do this, the left-hand switches are first all put back on busbar No. 1; then the right-hand switches are changed from Nos. 4 to 2, or 2 to 4, as the case may be. This test must be made while the machine is running as the balancer switches are always at neutral potential when the machine is shut down.

Booster Sets

In testing the meter on a booster motor, the same wiring arrangement holds good. These motors, however, are usually connected directly across the system from the positive to the negative side, and the connections for testing must be made on the side containing the meter shunt. If connected otherwise, it is obvious that the artificial load would appear on the standard meter only, while the actual motor load would affect both meters. Here it is assumed that the motor is running during the test, and this is, in fact, the safest way. If, however, it should be necessary to test the meter while the motor is idle, and the test must be made on the positive side of the system, it is all-important that the field excitation switch be thrown to the "busbar" position before closing the positive machine switch. Disregard of this precaution will result in a heavy short-circuit. This applies only to switchboards of the type under consideration, but it should not be understood that this "shutdown" method is recommended in any case.

Where meters are installed on the generators of a booster set, as they sometimes are, such meters should be connected as shown in Fig. 3, and tested with the machine idle. It would appear from the arrangement of the two sets of switches peculiar to a booster generator that it would be simpler to switch the "high" side in on busbar No. 4, to replace the jumper. This is not advisable

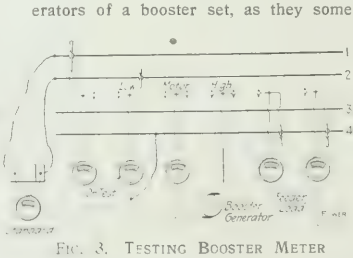


Fig. 3. Testing Booster Meter

however, as the testing current would have to pass through the armature and might be thoughtlessly increased to a large overload; also, if the machine could overcome its inertia and start up under these conditions, it would run away as a motor with no field. This, of course, could not occur if it had been previously started in the regular way and was controlled by its motor, but care should be exercised in that case not to excite the generator field and thus boost the feeders used for load. The use of the jumper is, on the whole, simpler and safer.

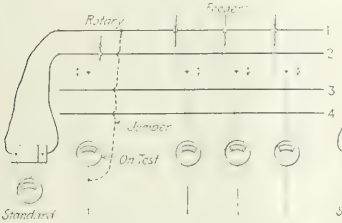


FIG. 4. CONNECTIONS FOR TESTING ROTARY CONVERTER METER

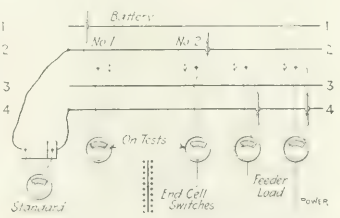


FIG. 5. TESTING BATTERY METERS

If the test must be made while the set is in service, connections similar to those shown in Fig. 3 may be used. Suppose, for instance, that the machine was boosting busbar No. 3, it will be obvious that the difference of potential between No. 1 and No. 3 will in no way interfere with the power required to supply the losses in the inverted machine.

It must be remembered that a machine run in this way has its neutral position shifted several degrees back; that is, in a direction opposite to that of rotation, and the brush frame must be shifted to this point to prevent sparking.

In some cases, where the meter to be tested is on the only machine available, it is found necessary to connect a jumper across the meter and standard, thus shunting part of the load, as indicated by the dotted lines in Fig. 4. This makes it possible to obtain a lower scale deflection than that of the full load.

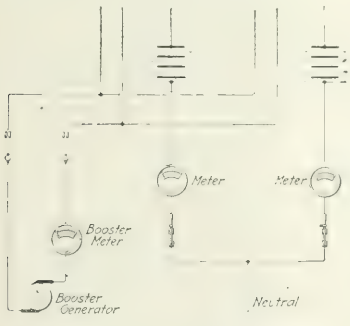


FIG. 6. METERS ON NEUTRAL SIDE OF BATTERIES

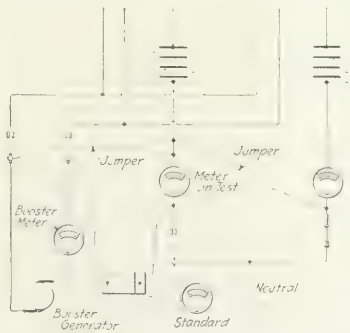


FIG. 7. AUXILIARY BOOSTER CIRCUIT USED FOR TESTING BATTERY METERS

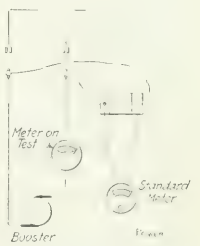


FIG. 8. TESTING AUXILIARY BOOSTER METER

the work if the connections are correctly made. The current measured under test in this case will evidently be that carried by busbar No. 3, plus whatever is thrown over to No. 4.

ROTARY CONVERTERS

In testing the ammeter of a rotary converter no feeder switching is required; it is only necessary to connect the standard meter as in Fig. 4, and throw the converter over to busbar No. 2. Then, having another converter running, the load may be shifted from one machine to the other; this shifting may even be carried so far that one machine will "invert" and run as a direct-current motor and build up an artificial load by feeding back into the alternating-current system. Therefore, the other converter will be carrying this heavy load and its meter may be checked at correspondingly high points. This does not mean that any extra demand is made on the alternating-current system as a whole, other than the power required to supply the losses in the inverted machine.

BATTERY AMMETERS

The battery in a substation is usually controlled by four sets of switches: positive No. 1 and positive No. 2, and negative No. 1 and negative No. 2. This does not necessarily mean that there are two batteries, but that the two extra sets of switches are provided simply for convenience in operating, and have their own end-cell switches at the battery and their own meters. This arrangement makes it possible to test the battery ammeters without charging or discharging, as will be seen by referring to Fig. 5.

By following the circuit from busbar No. 1, it will be evident that both of the meters will read, No. 1 indicating "charge," since the current is flowing toward the battery, and No. 2 indicating "discharge," as the current is returning through it. This current does not pass through the battery as the end-cell switches are both on the same cell contact, and are thus short-circuited on each other. It is important to see that this is the case before beginning the test, as otherwise the test current will pass through whatever cells happen to be included between the two switches.

With the busbar switches connected as shown, it is possible to calibrate meter No. 2 with precision, but the reading of No. 1 may be only approximately correct. This is due to the fact that there is usually a small "floating" current passing between the main busbar and the battery, and this current, although it affects meter No. 1, never reaches the standard meter. Meter No. 2, on the contrary, is in direct series with the standard meter and, if correct, should read the same.

The switches may be reversed without disturbing the feeder load if care is taken to switch in to the new position before pulling out of the old. The meters are now reversed, and No. 1 (which is now on busbar No. 2) will read "discharge" and be exact, while the other will read "charge" and be approximate.

The presence of this small disturbing current is, of course, unfortunate, but its value is nearly negligible, and if the reading is checked several times it introduces no practical error. Precise readings on the "charge" deflection can only be obtained by using less convenient connections or by charging the battery, which is not to be recommended.

Where a three-wire system is used, some companies install integrating ampere-hour meters on the neutral side of

the positive and negative batteries, at a position between the battery and the common connection to the neutral of the system (see Fig. 6). These meters are designed for both "charge" and "discharge," being provided each with two sets of integrating dials; they must therefore be calibrated under both of these conditions. Their position, however, is remote from the switchboard.

It sometimes happens that certain cells of a battery fall below normal voltage, while the rest hold up, and therefore means must be provided for charging these cells individually. This is usually done by running a separate set of two cables from one of the generators of a booster set into the battery room and continuing them above the battery as two bare copper bars. To these bars extension cables are connected and run down to the affected cells. This auxiliary booster circuit runs conveniently close to the meters, and has no arbitrary polarity like the buses. In fact, this booster circuit has been the only available source of current for testing these meters and gives a remarkably steady current at all loads.

The connections are shown in Fig. 7. As it is necessary under these conditions to open the neutral switch of the meter to be tested (the left one), the jumper shown on the right is used to maintain the neutral connection of the left-hand battery, and this must be done without including the meter, for obvious reasons. To reverse the current, the cables attached to the booster switches must be interchanged.

Individual Cell Charging Meters

The auxiliary booster circuit used in the foregoing test is equipped with an indicating ammeter as shown, and this ammeter might, of course, be checked for accuracy with the connections used in Fig. 7. When it is desired to test this meter only, the very simple arrangement shown in Fig. 8 will suffice.

In this as well as the last case, it should be noted that the booster generator is practically short-circuited and these tests should therefore be started on the weakest field possible; it may be built up afterward. A few points cut out of the rheostat will be sufficient under these conditions to bring the meter up to full-scale deflection or possibly overload the generator.

LETTERS

Too Much Compounding

A trouble with a small compound-wound, interpole generator which I was called upon to rectify may be of interest to other readers. The machine was a six-pole 40-kw. generator, running at 1200 r.p.m. It was designed to overcompound from 240 volts at no load to 250 volts at full load. The trouble experienced was that with the field rheostat set to give 240 volts at no load, when full load was thrown on the voltage would rise to about 290 volts instead of the 250 desired.

The first remedy tried, of course, was that of shunting the series field winding, but, while this helped somewhat, it was not nearly enough to correct the trouble. As an experiment, I cut out the series winding altogether, and was not surprised to see that with the shunt field alone, the voltage rose about 25 volts from no load to full load. This made it at once evident that the armature reaction must be boosting the shunt field; so I shifted the brushes forward several bars in order to make the armature reaction oppose the shunt field. On connecting the series winding in circuit again, there was no difficulty in obtaining the required degree of compounding.

I was, however, now confronted with a new trouble, that of bad commutation. As the natural shift of the brushes of a generator is forward, the only likely reason for bad commutation in the new position would be too strong an interpole field. Therefore, I weakened the latter by shunting it with a strip of german silver about 15 ft. long, having a section of 0.5x0.005 in. After that, no further trouble was experienced with either compounding or commutation.

L. S. Weil.

New York.

Chattering and Sparking Brushes

About 90 per cent. of commutator and brush troubles put down to faulty design are due entirely to lack of knowledge on the part of the men in charge of the plant. In order to keep a commutator in good repair, it is necessary that it should have the closest attention. Should the commutator commence sparking, it may be cleaned with a little kerosene, but too much should not be used as it is a very good insulator. Use sufficient to dampen a piece of clean rag and rub lightly across the commutator; if this will not remove the trouble, the brushes may be lifted, one at a time, and the bearing surface cleaned in the same manner as the commutator.

If the trouble is caused by a bad segment, it will be necessary to overhaul the machine. The commutator must receive the first treatment, after making sure that the trouble is not due to a short-circuited armature coil or a broken connection, which can be found by placing a galvanometer across the blackened segment. Now rub down the commutator with carborundum until the flat spot has disappeared, after which smooth off with sandpaper and polish. Next take out and thoroughly clean the brushes, and in reseating them place a strip of paper around the commutator; mark off where the ends meet, divide the paper into the same number of divisions as there are poles and again place this around the commutator. Now, if one of the brushes is placed to the mark on the commutator, it will be found to be slightly tipped and this must be fitted to the contour of the commutator. This is done by placing a strip of sandpaper between the brush and the commutator with the plain side against the commutator. It is then drawn backward and forward until the brush "toes the line" and makes a perfect contact with the commutator. After treating one brush on each pole in this manner the paper may be taken out and the other brushes treated similarly. Care must be taken not to place the brushes on the comumtator behind each other, but rather stagger them over the commutator so that the whole surface is covered.

When the brushes are finished they should be in perfect alignment axially. Before throwing the load on the machine the commutator must be wiped clean to make sure that no dirt has got under the brushes. Finally, the machine should be run without load with the brushes bearing on the commutator for some time. This will put a smooth surface on the brushes which will also help to polish the commutator.

Of course, faults may appear which are due to faulty design, such as weak insulation on the armature coils or soft mica between the segments, which burn away and cause the segments to be short-circuited, but, generally speaking, the trouble may be overcome by carrying out the foregoing instructions.

E. O'Shea.

London, England.

Thawing a Water Pipe

A 1¼-in. water pipe 900 ft. long froze on top of a hill and to thaw it out a 30-kw. 2300 to 122-volt transformer was used. The primaries were connected to the pole line through plug cutouts, and an ammeter was connected in the circuit. The 122-volt secondary terminals were connected directly to the pipe to be thawed out.

The circuit was connected to an idle alternator and the engine speed adjusted by throttling so as to make the transformer deliver about its full-load current. Regulating in this way from the station made it unnecessary to use any resistance in either the primary or the secondary circuit. The meters at the station showed 80 volts and 14 amperes [representing about 4¼ volts and 264 amperes in the secondary circuit—Ed.]. It took about four hours to thaw out the pipe.

Louis J. Gorilla.

Ironwood, Mich.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Deterioration of Suction Gas Producers

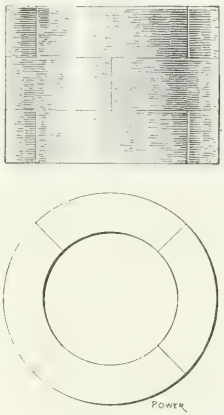
By J. A. Seager

It has been urged more than once against the use of suction-gas plants that, although for a time they appear to operate with considerable efficiency and satisfaction, they develop defects which after a few months' running cause very considerable trouble and in some cases lead to the redesigning or abandoning of the plant. It will generally be found, however, that such defects are traceable to causes which should have been foreseen, or if not should have been easily remedied at an early stage of the proceedings, and for this reason it may be claimed that the responsibility for many breakdowns of suction-gas plants rests quite as much with the purchaser and operator of the plant as with its designer and manufacturer.

Unfortunately for the prestige of this particular form of power source, it is largely adopted by people who are not technically expert and who may be located in out-of-the-way places where facilities for overhauling are somewhat limited even if the class of attention given to the plant is sufficient to detect faults in an early stage. Matters are therefore allowed to drift on until in the long run the trouble becomes so serious that it is almost impossible to remedy it.

The following incident will serve to show how very simply defects in suction-gas producers can be put right if they are taken in time. A suction producer and engine plant was installed under certain specifications as regards gas consumption. This engine, which was rated at 45 brake horsepower on suction gas, had a cylinder 13 in. in diameter and a 20-in. stroke and ran at 230 r.p.m. When it was first installed it averaged on a four-hour test run about 49 b.hp. and therefore showed a very good margin of power.

After it had been running for about nine months, however, some difficulty was experienced in carrying the load, and eventually it was found impossible to get the engine to take its full load. The matter was put in the hands of an expert, and on indicating the engine it was found that its indicated horsepower was between 48 and 49. Allowing the customary figure of 85 per cent. for the mechanical efficiency of the engine made the brake horsepower developed under the conditions of the second test about 41½. The engine was overhauled and carefully examined, but no defect was to be found in the engine itself. On inspecting the indicator cards, however, they showed "whale heads," indicating a weak mixture. This directed attention to the quality of the gas supplied to the engine and after a long search involving the overhauling of the generator it was found that the lining of the generator was leaky at certain parts of the joints; this allowed an excess of air to pass through, causing the weak mixture which reduced the horsepower of the engine.



A Good Form of Generator Lining

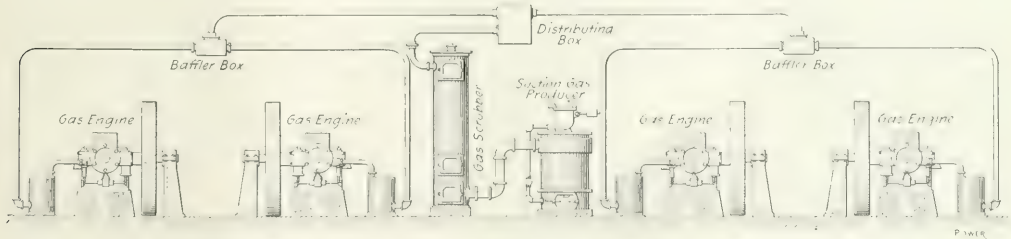
The indications seemed to show that the damage had probably been done by the too vigorous use of the poking bar when cleaning and stirring the fuel bed, and the very simple remedy was applied of putting gannister over the leaky places and black leading. This was a case, therefore, where, by reason of proper knowledge of what was required, the capability of the plant was restored with very little trouble. It may also be interesting to note that when suction-gas generators are being built it is always advisable to avoid joints in the lining as far as possible.

The accompanying sketch shows a very useful form of generator lining in which the material is built of quadrant blocks arranged in three tiers, the vertical joints being staggered. Where it is possible, in smaller sizes of generator, the number of joints can be still further reduced by utilizing blocks extending over 120 deg. each so that only three pieces are required in each tier. Generally speaking, the nearer the approach can be made to a monolith in the generator lining, the less likelihood there is of cracks developing which will allow undue admission of air.

Working Several Engines from One Producer

By W. E. Wort

A difficulty sometimes met with when attempting to run more than two units from one suction gas producer, is the tendency of one or more engines to get an irregular or insufficient supply of gas owing to a couple of the units synchronizing with their suctions, and so



Four Engines Run from One Producer; Distributing and Baffle Boxes Inserted in Line

causing a greater supply of gas to flow in their direction, owing to the stronger suction produced to the detriment of the supply to the other unit or units. This is very likely to occur where two units are run off one suction pipe at one end, and another unit is worked off the other end of the pipe.

The writer designed the arrangement shown in the sketch for working four 40-hp. gas engines from one producer, and in practice has found it very satisfactory. By the arrangement of baffles and expansion boxes it is as satisfactory when working one, two, three, or all four engines, although in this instance the gas producer was designed to supply two engines only.

It will be noticed that baffles or expansion boxes of large capacities have been fitted in the supply line by making the reservoirs nearest the engines about 2½ times the capacity of one of the engine cylinders; thus no interruption occurs in the supply to any of the engines.

A great benefit of the large reservoir near the producer (which should be about three and one-half to four times the capacity of all the engine cylinders) is that most of the dust and moisture are collected here, and, therefore, very little deposit is found in the other pipes or reservoirs, although the whole line of piping should be thoroughly cleaned out at least once a year. It is advisable to have drain cocks fitted to all the expansion boxes, so that the moisture can be drained periodically.

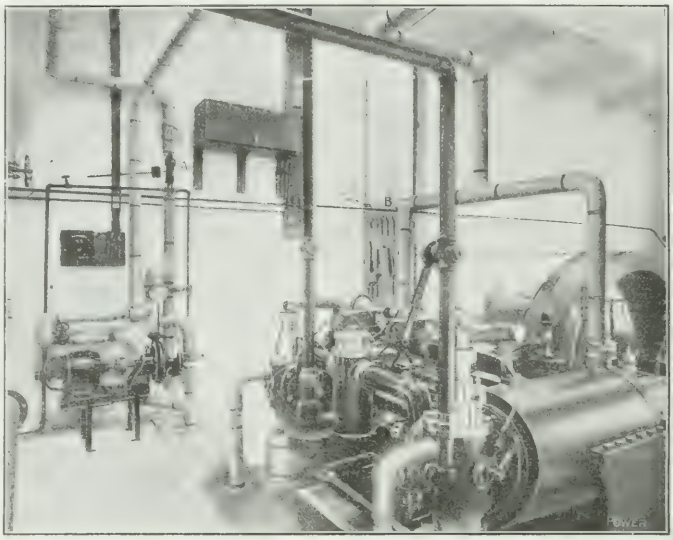
When working this installation the writer runs the producer on gas coke for the lighter loads, but for the heavier loads a proportion of anthracite coal is necessary, in the ratio of two of coal to one of gas coke. Of course, for the heaviest working, anthracite coal alone must be used.

Utilizing Waste Heat from a Gas Engine

An interesting method of factory heating is employed at the Hisey-Wolf Co.'s plant at Cincinnati.

The usual hot-blast practice is applied, using about 200 sq.ft. of heater surface, and in place of steam as the heating agent, the waste heat in the jacket water from a high-power gas engine is utilized. The water is circulated under pressure by an electrically driven rotary pump, through the engine jacket and a gas-exhaust water heater, then through a Vento fan coil and returns through the pump into the jacket.

Connected into the pump discharge is the city service line, which injects cold water into the jacket supply, under control of an Ideal siphon tank regulator, having its valve inverted to open with high temperature in place of closing. The thermostatic bulb of the regulator is placed in the flow pipe of the jacket water from the engines, and in this way the jacket water is held at the proper temperature. Referring to the illustration, *A* shows the main part of the regulator and *B* the stem (containing expansive fluid) inserted in the supply pipe and connected to the main part of the regulator by a flexible tube.



GAS ENGINE, PIPING AND REGULATING VALVE

As the jacket water must be held between 150 and 160 deg., a cast-iron boiler is cross-connected with the system to raise the temperature of the water in the fan coils in extremely cold weather, or when the engine is not running. The piping is so arranged that the flow from the boiler is directly into the fan coils and with the aid of the pump the proper amount is returned. It will also circulate by gravity independently of the pump and engine. Natural gas is used for fuel in the boiler, and the supply is automatically controlled. Also an automatic relief is provided to care for any surplus water in the system.

Explosion of a Diesel Engine

A short time ago a Diesel engine exploded at the United Machine Co.'s plant at Augsburg, Nuremberg, and resulted in several fatalities. From the report of the accident now made public it appears that the primary cause was the explosion of lubricating oil. There was an abundance of oil in the pump, and it had been carried into the receiver. A valve connecting the combustion chamber with the receiver was broken, and this brought about the ignition of the oil.

The explosion had a very slight effect on the machine, only parts of minor importance being destroyed. The greatest damage was wrought through the machine being surrounded by a scaffolding two or three stories high. The wood of this scaffolding during two or three months of experimenting had become saturated with oil and caught fire very easily. The receiver contained considerable oil which, after the explosion escaping in a burning state, set fire to everything around it not absolutely fireproof. The operators' clothes being greasy also caught fire. Had the explosion occurred to a machine fitted with iron gratings it would have passed without injury to anyone, and the damage probably would have been repaired in a few hours.

The loud report mentioned by the newspapers was not caused by the primary explosion but by a large vessel containing liquid oxygen which exploded through the heat. The whole affair was the outcome of several very unfortunate incidents which sometimes happen when new engines are tried.

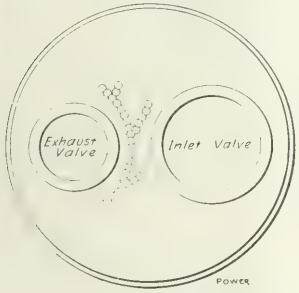
CORRESPONDENCE

Cylinder Head Repair

One of the cylinder heads on a 12x12-in. vertical gas engine developed a crack on the inside, between the inlet and the exhaust valve, both of which are in the cylinder head, and extended into the water space, letting the water into the cylinder and grounding the ignition points.

Something had to be done as the engine was needed badly, and as a new cylinder head would have cost $85, it

was decided to repair the cracked one. I accordingly drilled a $\frac{3}{32}$-in. hole at the end of the crack, tapping it with a ¼-in. tap, then selected a piece of No. 2 copper wire, threaded it for a distance of $\frac{5}{8}$ in. and screwed it into the tapped hole firmly. With a hacksaw I sawed it off, leaving the stud extending about ⅛ in., then drilled the next hole so that the drill just cut the edge of the first stud about $\frac{3}{32}$ in. This second hole was tapped and the next stud screwed in. Care was taken to always get a good thread in the previous stud, making the



CRACK MENDED BY SCREWING IN COPPER WIRE

repair look as in the illustration. With a small riveting hammer I riveted the studs down, making it a solid patch the entire length of the crack.

The main crack was 6½ in. long and extended open about $\frac{1}{16}$ in.; the smaller cracks were ½ in., 1½ in. and 1 in. respectively and thirty-one ¼-in. studs in all were required. The repair proved to be tight and cost only about a day's time with practically no expense for material.

M. W. UTZ.

Minster, Ohio.

Some Aspects of the Diesel Engine

The lecture delivered by Dr. Diesel before the American Society of Mechanical Engineers and which was abstracted quite fully in the May 28 issue of POWER, presented the results of experience running now over several years to show the economy of the principle, the lessened weight and bulk of the motor in marine service as compared with the combined steam engine and boiler and the gain in cargo space or in radius of action between fueling stations when oil is the fuel instead of coal. The case of fueling the vessel with oil as compared with the requirements with a collier supplying coal was notably made clear, and the convenient storage of oil fuel between the double bottoms of a steel boat and in spaces between bulkheads, where it not only steadies the vessel but is also in space otherwise unusable, was also a detail of interest.

The copious illustrations made it clear that the marine interests of Germany, Russia, France and Japan are far in advance of the United States in availing themselves of the economies and other advantages of the Diesel principle and in the use of oil for power; and the address concluded with a survey of some possible reasons why the Americans had allowed Europe to get in the lead.

The speaker specifically disavowed his responsibility as the originator of these explanations, but as coming from a friendly critic from outside, they were the more deserving of attention. Many engineers have acted in deference to their philosophy, perhaps without going to the extent of phrasing their explanations. Among them were the following:

The American has not yet felt the pinch of expensive coal to any extent. Fuel is costly in many places where transportation enters as a factor, but industrial America has developed near its fuel, and large plants have not been built on a large scale far to the north or to the south of the coal sources of the country. On the Pacific slope and in New England, the water power and the hydroelectric plants have been the satisfactory solution. The oil-fuel motor has grown only locally, on phosphate areas or in connection with remote mines.

The second and more important reason for the reluctance of the Americans was their attitude in favor of a low first or installation cost, even when the operating cost would be higher. The high compression pressure of the Diesel principle renders the best workmanship essential in construction. This quality of work is not cheaply obtained in America, or anywhere. Hence, the selling price of such an engine must compete at a disadvantage in the mind of a purchasing agent with the common or garden variety of motor, in addition to the obstacle of its being unfamiliar. Such a buyer must be shown and convinced that the difference in first cost of the familiar type and the new will be obliterated in time by the fuel-saving and that the interest on the difference in first cost will be more than paid in the yearly saving in fuel.

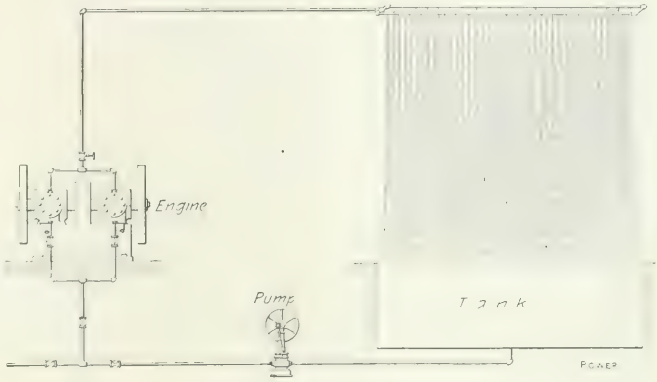
New York City.

F. R. HUTTON.

Cooling System for Jacket Water

Our plant is equipped with a 125-hp. gas engine and when I took charge, city water was used for cooling the cylinders. As from 7000 to 8000 gal. of water were used per 10-hr. day, I had a 6x6½x20-ft. concrete tank built in the ground and capable of holding over 5000 gal. of water. We filled this tank from the city supply and installed a 4x5-in. plunger pump to force the water direct into the water jackets of the gas engine. The return was led over the tank in two 1-in. pipes and sprayed through a row of ⅛-in. holes in each pipe to cool the water.

As these pipes are about 23 ft. above the tank, the water is kept cool enough to use over and over again, and by adding 500 gal. per day to make up for leakage and evaporation the tank is kept full all the time. The piping and valves are so aranged that the city supply can be used, should it be found necessary.



COOLING TANK AND ENGINE

This system has been in operation over a year and is very satisfactory; even in the hottest weather, we did not have any trouble in keeping the water cool enough. About 15 lb. pressure is carried on the line from the pump to the water jackets, and the tank is located about 30 ft. from the engine room. The arrangement has saved the company over $235 for the first year, and the installation complete cost only $150.

WILLIAM T. GARLITZ.

McKees Rocks, Penn.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Charging for Steam and Hot Water Service*

During the year the committee on steam heating of the National Electric Light Association sent out to a number of companies which are engaged more or less in the business of steam heating the following questions:

1. Do you heat by hot water or by steam?
2. If by steam, what is your net scale of prices per thousand pounds of steam?
3. Have you a net scale of prices per season for flat-rate service? If so, how are your prices determined?
4. What is the average cost of coal per ton of 2000 lb. in your town, also the average B.t.u. per pound of coal?
5. Do you consider the business profitable at these prices? If not profitable, do the resultant advantages in selling of electricity offset the losses on your steam business?
6. Do you have printed forms of contract for selling heat? If so, will you kindly furnish copies of same?
7. Do you furnish specifications to the consumer under which the equipment must be installed? If so, will you kindly furnish copy of same?

Nearly 100 replies were received and of this number about 75 were tabulated and presented in the report of the committee. Space is not available to publish the complete table, but reports from representative states have been included in the tabulation presented herewith.

In the replies to question 5 there was a fairly equal division of opinion as to whether the heating business is profitable or not. It was the general sense of the committee that a great many heating companies fail to properly figure their fixed charges on the cost of producing steam and that for this reason they have a fictitious profit. The steam company which is, perhaps, the oldest and does the largest business of any concern in the country, has adopted a somewhat higher schedule of rates than that of most of the heating companies. The fact that this company has done a large business on these rates would seem to support the contention that a great many companies sell steam at a lower price than they should. It would be well for each company, before determining its price, to make a careful estimate of its total cost, including the following items:

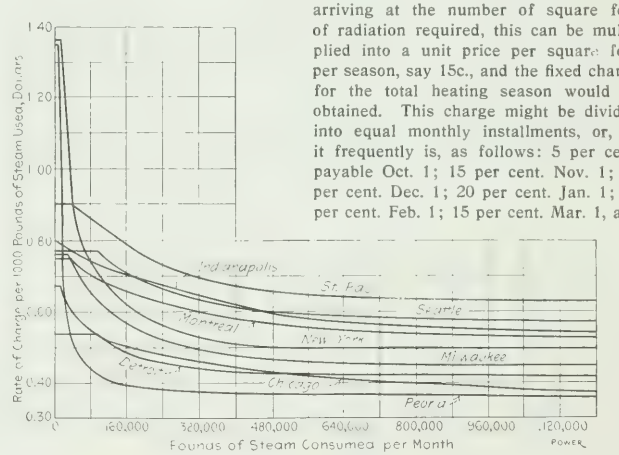
1. The cost of steam production in the plant.
2. The cost of steam distribution.
3. The cost of handling the business, including salesmen, collectors, etc.
4. General office expense.
5. The cost for insurance and taxes.
6. Depreciation and obsolescence.
7. Interest on the capital invested.

While the members of the committee recognize that at present the flat-rate method is the only practicable one for the hot-water system of heating, they agreed that the more satisfactory method of charging for steam-heating systems would be on the basis of meter readings. There was, however, some difference of opinion as to what extent the charge should be upon a meter basis. The simplest scheme is to make the charge depend absolutely on the amount of steam consumed, with a sliding scale for different amounts of steam consumed. In connection with the meter rate there should also be a minimum bill to secure the company against loss in installing and reading the meters.

There are many, however, who believe that steam heat should be sold on a basis corresponding to that of many lighting companies which have a primary charge and a secondary charge, the primary charge being a certain sum per month depending upon the size of the installation served; and the secondary charge being based on the readings of the steam meters.

A large part of the cost of most steam-heating companies consists in their investment for boilers, buildings, steam-transmission systems and their accessories. It is very evident that a factory running 24 hr. a day would make a greater use of the same investment than a church, or a theater which is used only periodically. Accordingly, on the same consumption of steam, there might be a profit to the company in one case and a loss in the other, depending on the investment cost as compared with the steam sold.

For steam-heating service, the primary charge could be based on the theoretical steam-heating requirements of the buildings served. For example, the company should first by the regular formula determine the proper amount of radiation to be installed in the building. After arriving at the number of square feet of radiation required, this can be multiplied into a unit price per square foot per season, say 15c., and the fixed charge for the total heating season would be obtained. This charge might be divided into equal monthly installments, or, as it frequently is, as follows: 5 per cent. payable Oct. 1; 15 per cent. Nov. 1; 20 per cent. Dec. 1; 20 per cent. Jan. 1; 20 per cent. Feb. 1; 15 per cent. Mar. 1, and 5 per cent. Apr. 1. In addition there should be a meter charge at so much per thousand pounds of steam, rendered each month on the basis of meter readings.



METER RATES FOR VARIOUS CITIES

In an interesting paper given by A. D. Spencer before the National District Heating Association in June, 1910, the author figured that the cost to the company in Detroit is practically 60c. per thousand pounds, including allowance for interest and depreciation. In the same paper he figured that the cost per square foot of radiation each year averages about 28.4c. He also showed in the same paper that the operating costs are just a little more than half the fixed charges. Therefore, the basis of the cost would be about 15c. per square foot of radiation per heating season, combined with a

*Excerpts from report of committee on steam heating read before the National Electric Light Association, Seattle, Wash.

meter rate of 30c. per thousand pounds as a secondary charge.

Byron T. Gifford, in his recent book on "Central Station Heating," figures that a central-station plant with an investment of $200,000 and a connected load of 200,000 sq.ft. of radiation, and with coal at $2 per ton, should have a service charge of 19c. per square foot of radiation, in addition to a meter rate of 30c. per thousand pounds of condensation. He figures on this basis an annual profit of 10 per cent.

The Wisconsin Railroad Commission, in its reports, Vol. II, page 302, states that with coal at $2 per ton exhaust steam can be safely sold at 50c. per thousand pounds. But it also states that if live steam is sold at this price there will be small profits unless large quantities of steam are sold. It would therefore seem, from the above data, that a fair average price for steam would be about 60c. per thousand pounds, or a combined rate of 15c. per square foot of radiation per heating season together with a meter rate of 30c. per thousand pounds for the secondary charge. This rate, however, is considerably higher than that secured by the average heating company.

The curves in the accompanying chart show the meter rates in different cities. These curves indicate that the average income received is considerably below the 60c. rate.

Enamel vs. Bronze for Radiating Surfaces*

Covering the surface of a radiator with paint or bronze affects the radiant heat only. The experiments made at the Royal Technical Institute, at Charlottenburg (Berlin), show that with low-pressure steam and a difference in temperature between the radiator and the surrounding air of 144 deg., a single-column radiator when painted with oil paint emitted 41.5 per cent. more heat than did the same radiator when galvanized with zinc inside and outside.

Peclet, the French physicist, who made exhaustive experiments on the radiating power of various bodies, calculated and tabulated corresponding coefficients, these being in each case the quantity of heat in B.t.u. emitted or absorbed per square foot per hour for a difference in temperature of 1 deg. F.

	Coefficient B.t.u.
Copper, silver-plated and polished	0.02657
Copper, polished	0.03270
Zinc and brass, polished	0.04906
Sheet iron	0.08585
Cast iron, new	0.6480
Cast iron, rusted	0.6868
Oil or varnish	1.4800

It may be noticed that the coefficient of radiant heat is about 50 times greater for oil or varnish than it is for copper, zinc or brass, the three metals which

*From "Ideal Heating Journal" of the American Radiator Co.

COST OF STEAM AND HOT WATER HEATING

Heat by	Price per 1000 Lb. of Steam by Meter	Price per Sq.Ft. of Radiation	Average Cost of Coal	Average B.t.u. per Lb of Coal
Alabama				
Steam	85c 1st 10,000 lb. 75c. next 10,000 65c. " 10,000 60c. " 20,000 55c. " 20,000 50c. " 30,000 45c. for excess Discounts: 10% 1st 100,000 lb. 15% next 150,000 20% " 250,000 25% " 250,000 30% for excess Average rate 42c.	Minimum monthly bill	$1.50	13,500
Illinois				
Steam	70c. 1st 25,000 lb. 60c. next 25,000 50c. " 50,000 45c. " 50,000 40c. for excess Discount 5%	42c 5% discount	$1.75	
Hot Water		16c	0.90	11,000
Steam and Hot Water		30c., and 27c over 2,000		11,000
Steam	60c	35c	0.90	12,000
Steam	75c. 1st 10,000 lb. 70c. next 10,000 65c. " 10,000 60c. " 20,000 55c. " 50,000 50c. " 200,000 45c. " 300,000 40c. for excess Discount 10%		2.75	10,000
Steam and Hot Water		35c., 25c. and 20c.	1.75	10,500
Steam		Flat rates	1.50	10,000
Steam	$1.50 1st 4,000 lb. 50c. for excess		1.10	
Steam	50c. 1st 5,000 lb. 45c. next 5,000 40c. for excess	Minimum monthly bill	1.10	
Hot Water		20c., 16⅔c., 15c., 12½c.		
Steam	75c. 1st 10,000 lb. 70c. next 10,000 65c. " 10,000 60c. " 20,000 55c. " 50,000 50c. " 200,000 45c " 300,000 Discount 10%	30c.	1.675	
Steam	$1.50 1st 4,000 lb. 50c. next 10,000 45c. " 20,000 40c. for excess Discount 10%	D. R. 27.8 bus. 33.3 res. I. R. 33.3 bus. 38.9 res.	1.25	10,000
Steam	45c		3.75	12,000
Steam and Hot Water	45c	28c	1.60	11,500
Hot Water		15c., 14c over 1,000	4.00	
New York				
Steam	50c. Discount 10%		$2.48	14,000
Steam	50c.		2.18	14,000
Steam	48c.		2.40	

Heat by	Price per 1000 Lb. of Steam by Meter	Price per Sq.Ft. of Radiation	Average Cost of Coal	Average B.t.u. per Lb. of Coal
New York—(*Continued*)				
Steam	60c. 1st 50,000 lb. 55c. next 50,000 50c. for excess Discount 10%		2.80	14,000
Steam			2.65	
Steam		5c per month	2.80	14,000
Steam	From $2.00 to 50c		1.90 to 2.40	
Steam and Hot Water	60c 1st 10,000 lb. 55c. next 10,000 50c. " 10,000 45c. " 20,000 42.5c. " 40,000 37.5c. " 250,000 35c. for excess Discount 5%		3.45	14,300
Steam	30c.—16.5 exhaust 50c.—24.0 live		2.20 2.30	13,500
Ohio				
Steam	36c. 1st 100,000 lb. 31.5c. next 150,000 27c for excess Discounts 20% to 40% to current customers	35c to 30c 10%	$2.00	13,000
Steam	75c. 1st 10,000 lb. 70c. next 10,000 65c. " 10,000 60c " 20,000 55c. " 50,000 50c. " 100,000 45c. " 200,000 40c. " 300,000 35c. " 300,000 30c. for excess Discount 10%	Minimum monthly bill		
Steam	35c. 1st 150,000 lb. 25c. next 1,350,000 20c for excess	25c.		
Hot Water		17.5	2.26	14,000
Washington				
Steam	77c. 7,143–100,000 lb. 66c. 100,000–200,000 55c. for excess	Service charge	Use oil	
Wisconsin				
Steam	90c. 1st 10,000 lb. 80c. next 10,000 75c. " 10,000 70c " 20,000 65c. " 50,000 60c " 200,000 55c " 300,000		$8.00 9.00	
Hot Water		25c	2.85	14,000
Hot Water		22c to 20c old business	2.60	13,000
Hot Water		Use	4.85	
Steam	76.0c. 1st 25,000 lb. 66.5c. next 25,000 57.0c " 25,000 47.5c. " 75,000 42.5c. for excess	Minimum monthly bill	3.00	13,500
Canada				
Steam	75c. 1st 25,000 lb. 70c. " 25,000 65c. " 50,000 60c. " 100,000 55c. " 100,000 50c. for excess		$3.50	12,000

fairly represent radiator bronzes. This indicates that metallic bronzes on the surface of radiation must have a tendency to check the flow of radiant heat.

The result of a large number of tests to ascertain the effect of bronze and radiator enamels on radiation is tabulated below:

INCREASED EFFICIENCY OF ENAMEL RADIATOR OVER SAME RADIATOR WHEN BRONZED

Kind of Radiator (All 38 in. high)	Per cent.
[illegible]	9.0
Rococo 2-column	17.0
Rococo 3-column	16.5
Rococo 4-column	15.0

Hundreds of experiments and tests have shown that radiator enamels increase the heating effect of cast-iron radiation. The secret of the increase lies in the varnish, which constitutes the body of the paint or enamel. The better quality of varnishes, which are made from high-grade resinous gums, make the best possible base for radiator enamels.

Color has no effect whatever; it does not matter whether the radiator is covered with white, black, red, blue, green or yellow enamels, the effect on radiant heat is the same. Radiators have been covered with four coats of white enamel, one on top of the other, and up to the last coat the emission of heat gradually increased. Putting on five or six coats does not increase the emission, nor does it seem to diminish it.

Criticize This Heating System

Fig. 1 shows the steam pipes used for heating one part of our factory, the pipes being located along one of the walls. There are eight 1¼-in. pipes 150 ft. long in the building, only four of which are shown. Exhaust steam is used for heating.

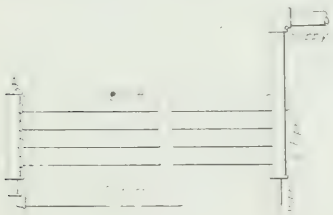


FIG. 1. PRESENT COIL

Last summer this building was lengthened about 50 ft.; the steam pipes were also continued from the old building up to the end of the new one, making the pipe 200 ft. long. As I expected to have trouble with these pipes due to their length, I recommended the installation shown in Fig. 2, but it was not adopted.

During the cold weather it was necessary to frequently repair many of the joints as they would leak considerably at the branching connections. This trouble was due to expansion and contraction, and at times some of the hook plates supporting the coils would be loosened from the wires. The building is heated only during the day.

After the heating season is over, the pipes will be changed to the arrangement shown in Fig. 2. Had this been done in the first place it would have been cheaper in the end.

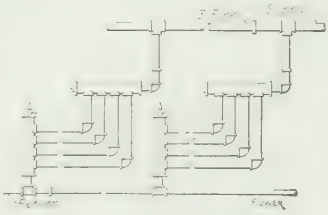


FIG. 2. PROPOSED COIL

Can any reader of POWER suggest an improvement over the method shown in Fig. 2?

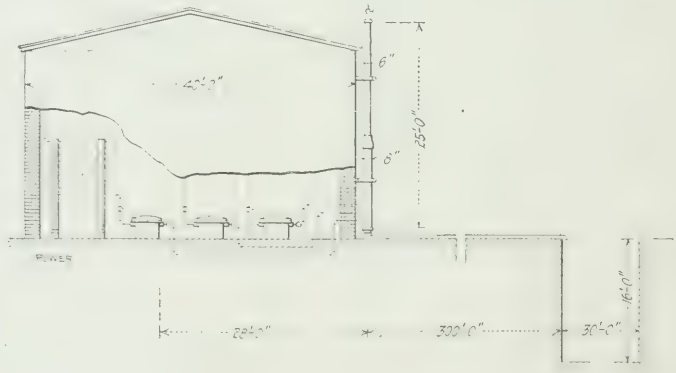
H. A. JAHNKE.

Milwaukee, Wis.

Draining Coils in a Dry House

The accompanying illustration shows the end view of a dry house that is equipped with 27,000 lineal feet of 1-in. pipe for radiating purposes. The drawing shows how the condensation from the coils is taken care of. This at times amounts to 10,000 gal. per 12 hr. The traps, which have 1¼-in. discharge openings, empty into a receiver at a height not to exceed 4 ft. above the trap.

The receiver is vertical and made up of 10 ft. of 8-in. pipe at the base and 15 ft. of 6-in. pipe for the upper portion, making a total height of 25 ft. The receiver is capped at both ends. The bottom cap is tapped for a 2½-in. pipe serving as an outlet from the receiver to a pool located 300 ft. from the receiver. The top cap is tapped for a ¾-in. valve connection.



DRAINAGE CONNECTIONS FOR DRY HOUSE

The object in having the receiver so high is to aid in condensing the vapor that rises from the hot water as it is discharged from the traps.

J. W. DICKSON.

Memphis, Tenn.

Cause of Pump Racing

I have had charge of steam-heating systems with pumps piped similarly to that described by W. T. Moulton, and when they raced it was almost always due to vacuum in the system. With a heating system using three return-tubular boilers, each 66 in. x 18 ft., a ¾-in. vacuum breaker is not large enough to entirely prevent vacuum in the system, for it will take some time for the system to fill with air through that size of pipe.

With 4 lb. pressure and a dry return, the water will be very hot, and if the pump is only a foot or two below the tank, it might race with the drop in pressure from 4 lb. to atmosphere even without a vacuum. The racing is due to the temperature of the water in pump suction pipe being above the boiling point at the reduced pressure and the pump fills with vapor instead of water. If Mr. Moulton could get a vacuum gage he could tell how the pressure varied.

With a closed heater the make-up water can be put into the return tank cold, thus almost entirely removing the trouble. If the pump could be placed low enough, the racing could be stopped, but in many cases that is not possible. In case a pump is lowered, use a larger pipe for the vertical drop under the return tank, and steam forming in it will escape up into the tank.

By using a vacuum gage, lowering the pump or perhaps opening the back-pressure valve to be sure the 4-lb. drop is enough to make the pump race, Mr. Moulton can readily tell if it is advisable to make any changes.

HARRY D. EVERETT.

Ft. Apache, Ariz.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Blk., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Effect of Stiffness of Head on Braces

Away back in 1876, Samuel Nichols, a practical boiler maker in charge of a large English works, wrote a book for boiler makers. In it he recounts some experiments made under the supervision of Robert Nelson, author of "A Treatise on Steam Boilers," upon boilers built by himself for the purpose, with regard to unstayed heads in cylindrical shells. A boiler 30 inches in diameter with flat heads ⅜ of an inch thick, of plate having a "tenacity" of 21.2 tons per square inch with an elongation of 7.9 per cent., flanged on a radius of one inch inside the plate, was subjected to hydrostatic pressure. At 10 pounds the head had bulged $\frac{1}{16}$, at 120 pounds $\frac{11}{16}$ and at 150 pounds $\frac{13}{16}$ of an inch. Permanent set occurred somewhere between 50 and 65 pounds, at which latter figure the deflection was ⅜ of an inch. Rupture took place at about 300 pounds.

From the results of his tests, Mr. Nichols deduced a formula which is printed in his book for determining the bursting pressure of cylinders with unstayed heads, although he strongly disclaimed any advocacy of exposing an unstayed surface to high pressures. "On the contrary," he writes of himself, "he is more convinced, now that he has witnessed these experiments, that a flat unstayed surface is very weak indeed, and that they still require a larger amount of care and judgment on the part of boiler engineers than any portion of the boiler."

Evidently under the erroneous notion that if the head can take care of the amount of pressure indicated by this formula on its own account it will need corespondingly less bracing, the Board of Boiler Rules of Ohio, after instructing inspectors to determine the working pressure of boilers with respect to the bracing in the usual way but with an allowable stress of 8000 pounds per square inch irrespective of size, tells them, "To the above pressure may be added the Nichols formula with a factor of safety of not less than 8."

If this means, and it can seem to mean nothing else, that to the pressure which can safely be taken care of by the bracing may be added the pressure which, by the Nichols formula, would be allowed upon the unbraced head, it is wrong.

Mr. Nichols shows that the head may be bulged considerably without straining the sheet beyond the elastic limit. But a brace is supposed to be tight before the head commences to bulge. Just as soon as the head starts to move it commences to stretch the brace. Under the allowable stress of 8000 pounds per square inch of section a brace will extend only about $\frac{1}{3750}$ of its length, or a six-foot brace would extend less than 0.02 of an inch. The pressure which would produce the movement in the unbraced head is inconsiderable—a pressure of 10 pounds produced a movement of three times as much—and yet this is all the help that the stiffness of the head would be to the brace.

As an example, assume a 72-inch boiler, height of segment to be braced 24 inches, area of segment to be braced 814 square inches, pressure 100 pounds, thickness of head ½ inch, tensile strength 60,000 pounds.

The Nichols formula with a factor of safety of 8 would allow

$$\frac{t \times T \times 10}{A \times 8} = \frac{0.5 \times 60{,}000 \times 10}{814 \times 8} = 46 \text{ lb.}$$

If this may be added to the pressure which the bracing is capable of carrying, it would be necessary to brace against only 100 — 46 = 54 pounds per square inch, which at 8000 pounds per square inch would require seven 1-inch braces. Practice calls for at least twice as many.

Flue Gas Analysis

An engineer recently complained that POWER devoted too much attention to flue-gas analysis, concluding his objection by observing that not one engineer in a thousand could take a gas sample and analyze it.

These two statements are rather contradictory. POWER can hardly publish too much about CO_2 apparatus or the method

of determining the contents of flue gases, if engineers generally do not understand flue-gas analysis, and it is true that they do not.

Twenty-five years ago the indicator was a curiosity to most engineers. The man who owned one was called an indicator expert and was engaged to set engine valves for the man who did not own an instrument.

If engineering journals had remained silent regarding indicator practice, the indicator expert would still be in evidence, and the majority of engineers would still employ him to set the valves of their engines. Publicity educated engineers as to the value of the indicator, its use, and application. Today engineers who either do not own an instrument or know how to take indicator diagrams are in the minority.

In twenty-five years, probably less, flue-gas apparatus will be as well understood as is the indicator today, not so much because the device itself will attract attention as that articles, and more instead of less of them, will be published.

If improper combustion is taking place the engineer should be as keen in detecting that as he is in determining leakage past a steam piston. An indicator shows what is taking place in an engine cylinder. A CO_2 recorder shows what is taking place in the boiler furnace, and one is just as important to the engineer as the other.

No! POWER has not published too much about flue-gas analysis—rather too little if anything. More will come and the subject will be presented to our readers until it will be as common to find men analyzing furnace gases as it for them to take indicator diagrams.

After Honors, What?

No recent record of heroism has outshone that of the "humble toilers of the sea" at the time of the "Titanic" disaster. And looming large in the forefront were the engineer and boiler-room forces of the ill-fated ship.

A fair meed of recognition has been given them and now grateful survivors have honored the "Carpathia" crew by bestowing upon them medals in commemoration of their "coming out of the dawn" to save human life.

At the reception of the survivors' committee on board the "Carpathia," details of which are given on page 855, Capt. Rostron said: "I do not deserve this credit. It belongs to my crew for their loyalty, valor and fidelity to duty; they have brought this honor to me."

There they stood, engineers, firemen and coal passers, grimy and toil-stained as they came direct from their posts to join their officers in receiving tokens of bravery. "Thank you, sir," was all they said. What did they think?

They had been rewarded, but will their deeds soon be forgotten? Will the lesson taught by the "Titanic" horror awaken the authorities to their culpability and arouse them to take measures to prevent its repetition? Will heed be given to the Senate investigating committee's report?

Here are Chairman Smith's concluding words: "These men should be better paid for their labor and more highly honored in their calling. Their rights must be respected and their work carefully performed; harsh and severe restraining statutes must be repealed, and a new dignity given this important field of labor."

Not until these conditions are brought about will the men of the sea receive proper recognition for their devotion to duty and their vocation be held dignified and gravely responsible.

Calking Steam Boiler Joints

On page 846 a contributor, in calling attention to the ill effects of heavily hammering the calking tool when closing a leaky joint, states that many engineers make this mistake. Perhaps some of them do not do the work properly.

Superficially, the general opinion seems to be that calking a joint is simple, but if the work is not carefully done disaster may follow, especially if the boiler is under pressure while being calked. A sharp-pointed tool should never be used as a thin portion of metal is then driven between the plates and only increases the size of the fissure.

Grooves are also formed which enlarge rapidly under the combined action of corrosion, expansion and contraction. If extremely hard blows are given the tool and the joint is already badly corroded, serious results are inevitable. Such ignorant use of the tool will also stiffen lapped and single-strapped butt joints and create a local and intense expanding and contracting action which results in forming cracks under the lap. A round-nose or, better still, a fullering tool should be used, but not subjected to heavy blows.

A Contemptible Fraud

It was recently discovered that a fireman in a large plant nearly closed the steam blowers on his boilers to hold his fires longer, puting the necessity of more frequent firing on his mate.

How long this despicable thing might have continued before detection is a question. The offender could have long avoided being discovered, especially in a busy boiler room, by only partially closing each blower valve. This not only made his fellow workman do part of his work for him while he undeservedly received pay for it, but it forced the other man's boilers as well, and it was only when he overdid the thing that he was discovered.

It is mild indeed to say that such an act is on a par with stealing a man's lunch or opening his locker and taking his clothes or valuables.

Wilbur Wright

Motive power was necessary to the success of the aëroplane, and credit for its successful application to this form of conveyance belongs to the brothers Wilbur and Orville Wright.

The steam engine as applied by Prof. Langley to his "aërodrome," which unfortunately plunged into the Potomac, exerted an accelerating influence on the Wrights' achievements. From Langley's experiments, perhaps more than from any other source, was Wilbur Wright able to discern that power was indispensable to an aëroplane. Truly his success in applying it entitles him to the recognition given to other notable inventors. His loss to the science is great.

The recent meeting of the Mechanical Engineers at Cleveland brought out three papers big with interest for the power-plant engineer. Mr. Weymouth's paper on "Natural Gas" is a collection of data hitherto not widely available. Prof. Christie's paper upon "Large Steam Turbines" is an epitome of the present state of a rapidly growing art, but Prof. Clayton's "New Method of Analysis for Indicator Diagrams" is a discovery.

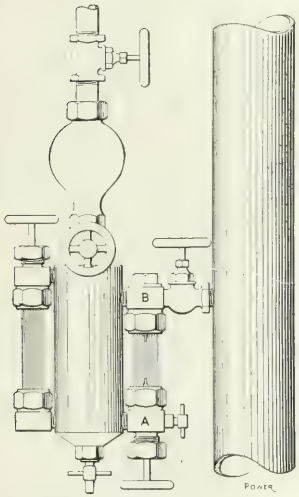
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Lubricator Troubles

Formerly when I went into an engine room and saw the sight-feed glass of a lubricator blocked up, I thought the engineer a shiftless fellow. I would say: "He is just slovenly and careless; he can fix that lubricator so it will work well and look neat if he wants to." Sure, anybody can! What is a gravity lubricator, anyhow? Simplest piece of apparatus in the engine room.

My friends have often heard me express my opinion on this subject and for that reason when they come to visit me on the job, I quickly pass by the 18 and 10 by 12-in. duplex force pump,



LUBRICATOR CONNECTIONS

with the lubricator connected as shown in the sketch, because the sight-feed glass was blocked full of oil and I did not want to have them criticize me.

During the last six months I have cleaned that glass out twenty or more times a day, depending on how much time I had. I have cleaned the drop nozzle, filled the glass with ammonia and water, salt and water, kerosene and water; fastened a piece of metal from *A* to the steam pipe to keep the oil warm and thin, but all to no avail. The oil would drop clear a few times, then catch on the side of glass.

While working on it the other day I broke the glass, and when I put in a new one and attempted to tighten it I broke that also. Then I investigated (which I should have done before) and found that *A* had become turned so as to bring it out of line with *B*. The result was that the oil traveled from the nozzle in *A* up against the glass and discolored it. I turned it in place and now my troubles are ended. I have learned to be more lenient in my criticisms too.

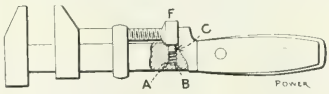
A. W. GRISWOLD.

Adams, Mass.

Improved Monkey Wrench

When a monkey wrench is no longer new it usually works so easily that it tends to shift its adjustment. I have overcome this trouble by removing the handle and screw and drilling a $\frac{7}{16}$-in. hole as at *A* in the illustration. Into the hole is inserted a spring *B*, the tension of which should not be too great. On the end of the spring the plug *C* is placed so that it binds against the knurled roller *F*.

This kink works most satisfactorily when using the wrench in cramped quart-



IMPROVED MONKEY WRENCH

ers. It may be further improved by drilling a number of depressions the size of the face of the plug into the roller. The spring would then force the plug into the depressions and hold it more firmly.

JACOB LUSTENBERGER.

St. Joseph, Mo.

Restricted Flue Opening Causes Poor Draft

At one station in our system of water supply, there was trouble in keeping up steam to run the engines. As one part of the city depends upon this station for its water supply, it can be imagined what shutting down this station would mean. When the storage supply began to diminish, the officials became anxious and the chief of the department invited me over.

An examination of the fires proved that the trouble was not with the coal, as had been suggested, but with the draft. I could not find a damper in the flue to the stack; then I looked for some opening into the flue and found a small plate and raised it; the flue contained about 18 in. of soot.

I figured this much soot was not the whole cause for the poor draft as the flue was large. I then put a long dry stick down into the flue through the soot. When the stick was withdrawn the real cause for the poor draft was revealed, the stick being wet to a height of 2 ft., which added to the 18 in. of soot reduced the vertical diameter of the flue 3½ ft.; this was too much for the work expected of it. When the water was pumped out things improved. There has been no further shortage of steam.

H. R. BLESSING.

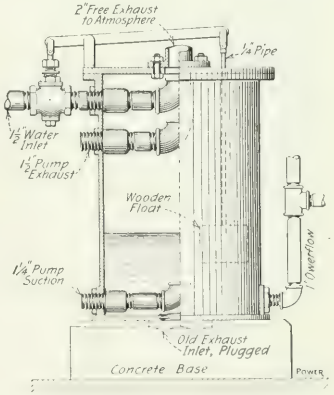
Philadelphia, Penn.

Serviceable Feed Water Heater

The accompanying illustration shows a home-made feed-water heater which I constructed from material gathered from the junk pile.

Having on hand the old shell of a closed heater, I decided to use it in making the open heater shown. The illustration shows the material used and the arrangement of the various parts.

A 4½ and 2¾ by 4-in. duplex feed pump and a 6 and 4 by 6-in. service pump exhaust into the heater and produce a



HOME-MADE FEED WATER HEATER

feed-water temperature of nearly 212 deg. F. The surface water from the condenser enters the heater at about 100 deg. Approximately 2000 lb. of water per hour is heated. An oil trap is not needed with the heater.

The total cost of construction did not exceed $15.

W. H. BENNETT.

Seattle, Wash.

Repairing a Cracked Pump Cylinder

We repaired a cracked pump cylinder by drilling a hole at one end of the crack and tapping out for a ⅜-in. plug. We then drilled another close to the first one, letting the drill extend into the first plug about ⅛ in. The second hole was then tapped and plugged, and the method continued until the crack was covered. It was then smoothed off with a file and calked. Straps ⅜ in. thick used with iron cement further secured the job.

The pump has been running for some time with a 110-lb. pressure without signs of leaking.

F. H. Coleman.

Milledgeville, Ga.

Waterproof Cement for Belts

To put waterproof cement on belts requires more care, time and skill than to put on ordinary glue cement, but this is justified as the belt can be used then where a rubber belt would be ordinarily.

Unlike glue, the waterproof cement is used without heating and evaporates quickly; two coats of the cement are needed for a successful job. It gives the best results on good dry oak leather, but it must be dry and free from oil, as no cement will make a strong job on an oily surface.

The lapping ends must be cut straight and at the same angle to make the thickness of the joint uniform and equal to that of the body of the belt, as the joint must be effected by a steady pressure and not by hammering nor rubbing. The point of the lap uppermost should be about ½ in. thick and a corresponding depression cut across on the heel to receive it. This allows the cement to impregnate the grain at the point and makes a stronger and better joint.

When the laps are made, scraping both surfaces of the lap raises the fibers of the leather and makes the cement more effective. As the cement evaporates rapidly when exposed to the air, only a little should be poured out at a time and preferably into a narrow, deep can. With a clean brush the surfaces should be given a good coat, working the cement well into the fibers. The second coat should not be applied until the first dries thoroughly, say from 30 min. to an hour; it will assume a grayish-white appearance when dry.

At this point a press clamp is needed which should be the same length as the clamps used to pull up the belt, but flat, about 4 in. wide on the face, and covered on both clamping surfaces with sheet rubber or felt. Bring the two lap surfaces together and tack one end when the laps lie straight, mark 4 in. from the other end and put the press clamp at the edge of the 4-in. mark; then raise the end of the lap and cement the 4-in. strip thinly and evenly and slide the press clamp over on the joint and tighten evenly and firmly. Let this set for 15 or 20 min., then loosen the other end, lift the lap and mark 4 in. ahead of the press clamp, loosen the clamp, then cement 4 in. and slide the clamp over and tighten it; cement just the width of the clamp each time until finished. The joint must set six hours before putting any strain on it.

When using waterproof cement keep it away from a flame or open light, as it is highly inflammable.

John F. Cochrane.

Norwich, Conn.

Calking Steam Boiler Joints

In calking steam-boiler joints many engineers make the mistake of heavily pounding the tool until further effort to stop the leak seems futile. With a high pressure in the boiler this method aggravates the leak as the internal pressure tends to open the fissure.

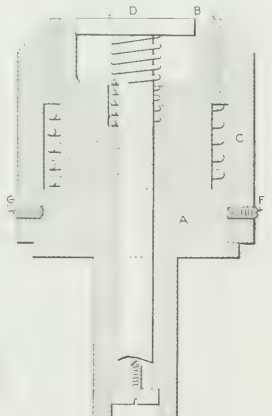
In calking, the point of the tool should be set a trifle above the joint and light blows applied to it. This will bring the plates together and materially lessen, if not entirely stop, the leak.

Lloyd V. Beets.

Nashville, Tenn.

Punch for Making Washers

The illustration shows a tool for cutting washers from packing, which is cheap to make and very effective. Parts *A* and *C* are made of Ketos steel and shedders *B* and *D* are of machine steel. Parts *A* and *C* required no grinding after hardening as they did not change in size and assembled without any trouble. Part *C* is a driving fit on part *A* and is also held by two setscrews *F* and *G*. The washer is ejected by a shedder *B* and the scrap is forced from the center by shedder *D*. This tool is used in the punch press and strikes a machine-steel piece held in a bolster, thereby saving the cutting edges of the punch and completing a first-class job.



Punch for Cutting Washers

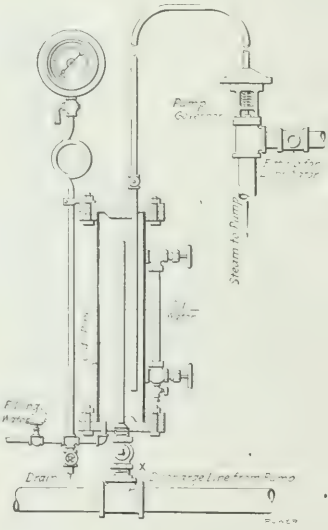
Walter Edwards.

West Philadelphia, Penn.

[Ketos steel is a tool steel adapted to making dies, taps, etc., which may be hardened with very little distortion.—Editor.]

Separator for Oil Pump Governor

In the throttling control of pumps handling such fluids as fuel oil, which sometimes tends to become sluggish and clog, a separator device may readily be made by means of which clear water can be used as a pressure-transmitting medium between the valve-chamber bonnet, header or discharge piping and the pump governor. This not alone secures a more sensitive regulation, but by the introduction of pure water in the case of a governor containing a textile diaphragm the latter will last indefinitely, whereas fuel oil will soon cause it to deteriorate; the pressure gages in the above apparatus will also be kept clean and in better order.



Separator for Pump Governor

The illustration shows a device which can be readily constructed. It is desirable to include a permanent water-supply connection from a source of moderate pressure as it will obviate the more tedious task of filling the chamber through a funnel. By selecting extra-heavy fittings and 1-in. nipples at *X*, no bracing is necessary if excessive vibration is not

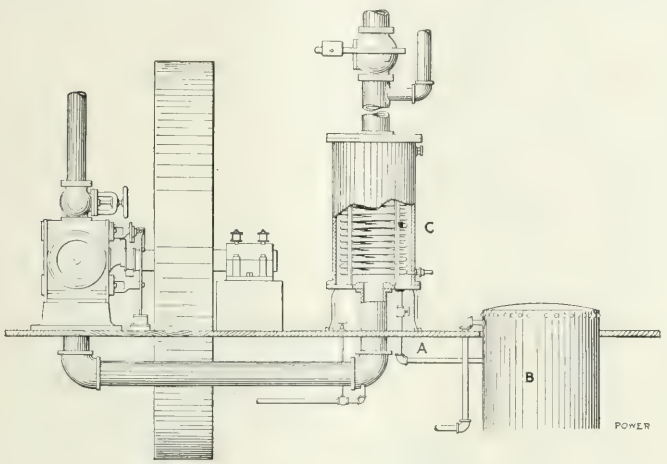
present in the discharge line. The apparatus is particularly desirable in the contol of heavy fuel fluids to steel furnace burners, and its application to other service is obvious.

B. G. STEWART.

Kansas City, Kan.

Heater Acted as Jet Condenser

The layout shown in the accompanying illustration caused me no end of trouble on several occasions. Without warning, this 16x48-in. Corliss noncondensing engine would act just as though someone had cut the main belt, suddenly relieving the engine of its load. The engine would practically double its speed for a period of about 12 sec., during which the slack side of the belt would flap violently and all the smaller belts would screech, due to the sudden increase in speed.



PIPE CONNECTIONS TO HEATER

The general conditions of the plant were such that it did not invoke surprise no matter what happened. The engine was said to be 52 years old, and everything else was in harmony with the engine.

After a thorough investigation I found that the drip *A* went into the blowoff tank, and when the water rose above the end of the drip, the velocity of the exhaust steam from the engine in close proximity to the heater drip *A*, caused the water in the tank *B* to be drawn up into the heater *C*, mixing with the exhaust steam and thereby creating a partial vacuum. As the drip *A* was only 1¼ in. in diameter it was not long enough to maintain a vacuum of about 8 in. for a longer period than 10 or 12 sec., thereby causing the heater to act as a jet condenser. After I changed the drip from the tank to where it could get no water over the end, there was no further trouble.

A. C. WALDRON.

Revere, Mass.

Welding a Cracked Furnace Door

I applied the autogenous process of welding to a crack in the firedoor which extended through the rivet hole from the edge of the plate to about 4 in. beyond the rivet hole.

The rivet in the hole through which the crack passed and one on each side of it were taken out and a wide V-groove cut along the crack, almost through the plate and about ½ in. beyond the end, leaving a thin sheet of metal $\frac{1}{16}$ in. thick to weld against.

The flame of the welding torch was then applied along the crack and mild steel melted in it until the crack was filled, every inch or so being hammered smooth with the sheet. The rivet hole was also filled and later drilled out for the rivet.

After the crack was filled and smoothed over, it was annealed, the rivets replaced, and the boiler put into service. The operation was entirely successful.

ROBERT VOSS.

Holyoke, Mass.

What Cuts the Top of the Cylinder?

A very elusive knock which appeared and disappeared without any apparent reason developed on the high-pressure side of a 1000-hp. Corliss engine. When running with a full load the knock was slight or entirely absent, and at times it would be heard when the load was light; in starting and stopping it was severe. Our efforts to locate the cause were futile, and though we thought several times that the trouble had been located and cured, the knock came back. We took out the boxes and scraped and adjusted them carefully, tested for loose pins, loose crank, piston and follower plate, but everything was tight and the clearance was correct. Finally the builders' expert went over everything, took up a little more on the crosshead shoes, but he left the knock, and all the time it was growing worse.

About a week after, trouble was encountered in the metallic packing of the piston rod, to remedy which it was necessary to take out the piston and rod. When this was done, the interior of the cylinder showed the cause of the pound. Although the bottom of the cylinder was in fine condition, there was a shoulder worn at the top of the back end. A like shoulder also existed at the head end, but on account of its position it would not be noticed except by very close scrutiny. When the cylinder had been looked into, the bottom appeared so fine that there had been no thought of cutting.

At a line along the middle of the top of the cylinder the cut was about ⅛ in. deep and this shaded off to nothing on each side at about 50 deg. from the middle line. Next it was found that the rings had fared even worse, nearly ⅛ in. being worn from them practically all around. As each piston has only one sectional ring, it does not reach the counterbore; hence the shoulder.

As the ring was new, the builders were told that they had used a wrong kind of iron, but they denied this and came back with the claim that we used poor oil, but it was tested to specifications; moreover, on opening other engine cylinders no sign of such trouble was found. It certainly seemed to be due to the new ring.

The cylinder was rebored, a new piston was put in and for a time all went well until about four months later, when more trouble loomed up. Another engine is now ready for the boring bar and the rings are badly worn, two of the cylinders show considerable wear and the one where the trouble started has rejoined the list. The cylinders invariably cut on top, and in all cases the rings are badly worn. Superheated steam is not used.

We have found the cause of the pound, but what is the cause of the wear? The engine builders are now released. The boiler compound is under suspicion, but the makers positively assure us that there is nothing in it that could cause such trouble. Even if that is the source, why did the trouble appear in one cylinder so much earlier than in the others? Another engine taking steam through the same separator is even yet unaffected.

Why are not all the engines equally affected? Why do the cylinders cut on top? Why do the rings wear away so fast?

WILLIAM E. DIXON.

Malden, Mass.

Putting in a New Crankpin

It was decided to put a new crankpin on the low-pressure side of a 250-hp. Corliss engine. To get the old pin out, a number of holes were drilled in the ends of the pin near its circumference, and it was then driven out. A new pin was turned out and finished 0.004 in. too large and given a slight taper.

Three pieces of shafting were turned to fit the hole and heated in a portable forge. The crank disk was heated red hot on one side by inserting the hot pieces of shafting in the hole. When the disk was red hot, the new pin was driven in with a sledge-hammer using a brass bumper.

The engine was connected up and started without giving any trouble, and the new pin, put in about nine months ago, is still doing good work.

CLAIR A. GILSON.

East Lansing, Mich.

Timely Examination of Leaks

Some engineers and steam-fitters allow leaks on high-pressure steam and water lines to continue, not realizing how serious they may be.

One morning I noticed a small leak in one of the joints of a ½-in. nipple which connects a globe valve to the main steam line on top of the boilers; this pipe furnishes steam to the factory. That night, after the steam was shut off and the leaky joint examined, it was found that the nipple was rusted and nearly eaten through at the threads. This nipple was cut from a length of ½-in. standard pipe and was only in service about two years.

I believe the quick wasting away of the nipple was due to the fact that very little steam is taken from this pipe and it is frequently full of water. Had I not removed the nipple that night, I am quite sure there would have been a shut-down at the plant the next day, due to the nipple breaking at the joint.

Another case was that of a 1x3-in. nipple in the lower pipe connection of a water column which started to leak at one of the joints. At night, after quitting time, the pressure was removed from this boiler and when the defective joint was examined, it was found that the nipple was nearly eaten through at the threads. I could not understand how it had held the pressure.

After this experience I made it a practice to test all pipe connections in the water column when the boiler was being cleaned by tapping lightly with a hammer. If a pipe or nipple showed signs of being defective, it was immediately removed.

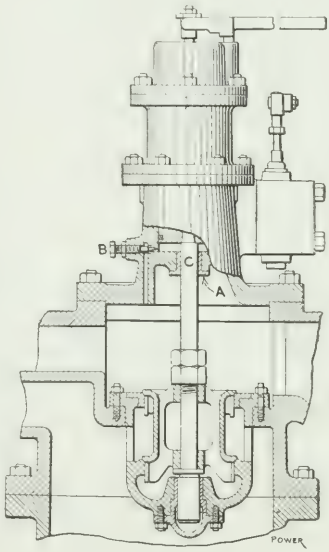
H. A. JAHNKE.

Milwaukee, Wis.

Turbine Repair

Our 500-kw. turbine would overspeed on light loads considerably. After trying several means of overcoming this trouble we finally decided it was due to steam leaking through the cylinder relay bushing *A* in the accompanying illustration, thus preventing the poppet valve from closing when the needle valve *B* was tightly closed.

Examination showed a clearance of 0.009 in. between the bushing and the spindle *C*. A new brass bushing was put



TURBINE POPPET VALVE

in to replace the worn cast-iron one. The clearance then measured 0.002 in. This seemed to be insufficient as the valve was not sensitive enough in its action, even though much steam was admitted through the needle-valve.

The trouble was effectively overcome by stopping the turbine and injecting oil through the needle-valve passage with a squirt gun. The valve has worked well ever since.

F. MARTIN.

College Point, N. Y.

Cleanliness and Mechanical Efficiency

A large Western concern having 25 or 30 power plants recently issued a bulletin containing the following paragraph: "A prize of ten dollars will be awarded to each plant employee having the best-looking apparatus, outside and in."

There is plenty of room for improvement in the appearance of nearly all power plants, and while I am strictly in favor of cleanliness, my argument is that a plant may be neglected in cleanliness and be superior in mechanical efficiency to one with everything shining and spotless.

For example, a boiler may shine with highly polished trimmings, valves, gages, etc., and at the same time be badly scaled, the valve stems need repacking, the tubes dirty and the water column nearly clogged up. An open feed-water heater may be spotless outside, and on the inside the baffle-plates may be so corroded that the perforations are filled, and possibly the coke or other filtering material has not been cleaned for months.

The bulletin is no doubt an inducement and a large factor in having employees keep the stations clean, but I believe that a plant should be judged by its mechanical efficiency first of all.

C. E. ALDRICH.

Mendota, Calif.

Reducing Labor and Filtering Oil

The engine in our plant is set upon a sub-base that rests upon a cement foundation. Inside the sub-base, just under the crank disk and connecting-rod, is an oil tray, which catches the oil drained from the crosshead, guides and crank disk. There is a ¼-in. pet-cock screwed into a hole in the sub-base just above the bottom of the tray; from this pet-cock the oil in the tray can be drawn off.

As the capacity of this tray was small and as much dirt collected and fell into it, I devised a plan to filter the oil and lessen the labor of frequently emptying the pan.

In a 6-ft. space under the floor I placed an old oil barrel, beside the engine foundation, directly under the pet-cock. Near the bottom of the barrel I bored a ¼-in. hole and screwed in a valve of the same size. I next sawed out a piece of the head about 8 in. square and fitted it with hinges. Then I bored a hole through the floor over the barrel and connected the pet-cock with a ¼-in. brass pipe, running it down through the hole in the floor into the barrel.

Whatever oil, water and dirt collected in the sub-base tray would run down into the barrel. I had already filled the barrel with water up to the height of the highest valve. As the oil ran into the barrel the dirt it contained would sink to the bottom of the barrel, leaving the oil clean. The oil or water could be drawn off at any time.

WARD T. MOULTON.

Portland, Maine.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Turbine or Engine?

The writer is particularly interested in your editorial of June 4, 1912, inasmuch as the Spiro turbine, of which he is the inventor, appears to be responsible to some extent for its conception.

Some objects which are complex in their nature may best be defined by describing what they are not. The absence of certain actions or functions is occasionally more restrictive than the presence of a large number of those more commonly shared.

If turbines were all alike in action, and possessed a common feature by which

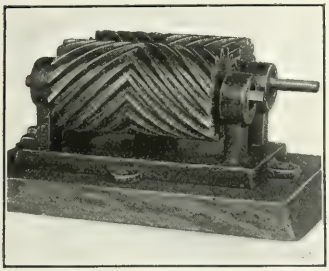


FIG. 1. A PAIR OF SPIRO ROTORS

they could be defined, it would be easy to dictate the limits outside of which a motor would cease to be a turbine. Evidently the editor selects "velocity action" as the defining element. The pile-driver Illustration is very apt in this connection, and certainly is analogous to the impact type of turbine where the initial velocities are high, ranging from 1000 to 4000 ft. per second, and the blade velocity only one-half the steam velocity. But how would this apply to the so called reaction type of turbine, such as the Parsons? Here the steam velocities are low, from 300 to 600 ft. per second usually, and the blade velocity practically equal to the steam velocity. How much effect would the blow of the pile driver have if the pile were moving as fast as the weight?

Evidently the "velocity" action will not do for the distinguishing feature.

Also, if it were possible to run a reciprocating piston engine at unlimited speed, the pressure action within the cylinder would decrease as the speed increased, and the velocity action would increase, so that in time the engine would be running under impact and the expansion would take place in the port which would correspond to a nozzle. But this increase in speed of action and consequent functional change could not be said to convert the piston engine into a turbine.

Just as it is practically impossible to give an intelligent definition of a human being, it seems impossible to rigidly define a turbine. Certain motors have, however, become definitely accepted by the engineering public as turbines, and others just as definitely established as engines. Let us analyze the established differences.

Turbines in general are distinguished by: high rotative and peripheral speeds; numerous blades, or vanes rotating about the axis; the absence of valves except as an adjunct of speed regulation, and extreme continuity of action due to the large number of blade efforts per revolution.

Engines, particularly rotary, are distinguished by: slower rotative and peripheral speeds; a few blades, or vanes rotating around the axis (rarely

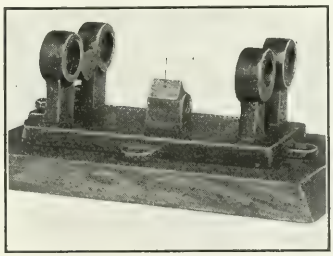


FIG. 2. THE INLET PORT OR NOZZLE

more than three in any rotary engine which has reached an operative state); the presence of valves, either reciprocating or rotary, and few steam efforts per revolution, corresponding to the number of blades.

There are exceptions to both classifications, and overlappings in some cases, but it is safe to state that if a motor partook of all the features described under "turbines" it would be proper to call it a turbine, whereas if it partook of all of the features stated above as peculiar to engines, it would be placed in the engine classification.

The impact turbine, as a class, has still another peculiarity which distinctly separates it from all other fluid motors—its ability to develop power and attain high rotative speed irrespective of its containing case. An impact turbine would operate as well without the case as with one, except that the steam, or other motive fluid, would escape into the room after leaving the wheel. This is not true of any other type of turbine, nor of a reciprocating piston, or rotary engine, so that if a motor possesses this peculiar feature, we may without argument place it in the impact-turbine class.

As to the Spiro turbine, there is no doubt in our minds as to its classification. Fig. 1 shows a pair of Spiro rotors mounted in bearings, and without an inclosing case or cylinder. Fig. 2 illustrates the inlet port or nozzle, there being two openings, one on each side of the central post, through which steam or air impinges upon the rotors. The opening on one side, indicated by the arrow, is so small as to be almost imperceptible in the engraving. This little model was made particularly to demonstrate the turbine action of the Spiro. As it stands, without a cylinder or case, and with 80 lb. initial air pressure, it develops a speed of 15,000 r.p.m. This is impact pure and simple, and places the Spiro without a cylinder in the impact-turbine class.

The addition of the cylinder adds another function—expansion—without detracting from the original impactive action. The range of speed in the commercial Spiro is from 1200 to 5000 r.p.m.; there are no valves, rotary or otherwise, except as adjuncts to speed regulation in the form of a governor throttle valve, and the steam action is perfectly continuous, due to the large number of blade efforts per revolution. In every respect it possesses the distinguishing features of a turbine as the term is known or understood, and the only argument that can be brought to bear against its being included in this classification, is that it utilizes the function of expansion within the tooth blades, notwithstanding the fact that expansion within the blades is a well known turbine attribute.

JOHN H. VAN DEVENTER.

Buffalo, N. Y.

Aid for Small Plants

More articles from men in charge of large power plants describing the operation in detail would help the engineer in the small plant to grasp their importance.

Necessity has compelled obtaining low cost for power production in the larger stations.

The smaller plants have not experienced the radical changes possible in the larger ones, and therefore show much less relatively marked improvement in their operation.

The reasons are clear, for with large interests in control they have been able to secure the best men in the field, who have, with capital behind them, been enabled to attack the cost of producing power from every angle, at an expense in many cases, even in proportion to its size and output, that would be prohibitive and disastrous to the small plant. Therefore, the men who can assist the smaller plants are most likely to be found in the larger ones, and they should be willing to give such information as would be practically applicable to the specific problems that confront the small plant.

The whole trend of things is to a greater economy and the conservation of the natural resources of our country. Let us have more letters from the big men.

R. A. Morse.

St. Joseph, Mo.

A Troublesome Condenser

In reply to B. A. Jacobs' letter under the above heading, in the Apr. 30 issue, if the condenser loses its vacuum with no outlet to the atmosphere, the steam pressure will rise in the condenser and exhaust piping until the engine stops or something breaks, and the condenser shell, not being designed to withstand internal pressure, will probably burst.

Mr. Jacobs' information is insufficient to more than guess at the cause of the trouble. The steam used per horsepower-hour should be known, the size, type, speed, horsepower, point of cutoff and steam pressure, and the degree of vacuum desired; the type of condenser, whether jet or surface; the temperature of the injection water, the quantity of injection used, and the size, type and speed of the vacuum pump; if a dry-air pump is used, and the diameter of the injection pipe.

There are a number of interesting points in his layout. The pump condensers are on the engine-room floor; therefore condensation from the exhaust steam cannot properly drain into the condenser, but will accumulate in the exhaust line until the pipe is filled sufficiently to cause the back pressure to force it through.

The suction lift is excessively high. With 26 in. of vacuum it is not good practice to lift the injection water more than about 20 ft. by suction. This allows a good margin of pressure to accelerate the water and to overcome friction in the pipe.

There are two unnecessary fittings and four joints in the engine-exhaust piping which retard the flow of steam and increase the likelihood of leakage.

The injection line is so shaped as to form an air pocket just before the condenser is reached, the air going over into the condenser at intervals and causing a fluctuation of the vacuum.

By placing the condenser below the engine, the condensation would drain off and the suction lift would at the same time be brought down to where it should be. The engine exhaust line could have been dropped straight down to the level of the horizontal pipe, thus eliminating the superfluous elbows and joints and giving a more direct flow, yet passing below the belt shown.

G. H. Bridges.

Holyoke, Mass.

There is little chance of the engine running condensing very long. With the lift given, the pump has a fair piece of work to perform. Why not have the pump discharge the water through the condenser instead of having the condenser connected in the suction line? This water can be discharged from the condenser into a hotwell or taken care of by another pump.

I have operated expansion pumping engines without automatic relief valves, or valves of any kind. In Mr. Jacobs' case his heater and condenser would soon be subjected to dangerous pressure if the vacuum was lost.

J. P. Colton.

Ohio City, Ohio.

If Mr. Jacobs would shut the valve between the exhaust line and the condenser, then try for a better vacuum, he might find a leaky suction pipe; if he obtains a better vacuum with this valve closed, it indicates leaks in the exhaust line. If the condenser loses its vacuum, the steam will blow back down the suction pipe and out through the suction and discharge valves of his condenser and through the discharge pipe.

Losing the vacuum will not harm the engine, but the condenser might be damaged. If the engineer was near-by, he could open the atmospheric valve and close the valve between the exhaust line and the condenser and prevent trouble.

Samuel H. Winterbottom.

Woonsocket, R. I.

Referring to Mr. Jacobs' inquiry under the above heading in the Apr. 30 issue, I would suggest that he search thoroughly for air leaks. If the condenser is of the surface type he may find the trouble in the air-pump valves. He complains of obtaining only 24-in. vacuum when the engine is idle. This, of course, depends upon the altitude, as 30 in. can be obtained only at sea level and the altitude of Frankfort, Mich., may account for the seemingly low vacuum. The best vacuum I have seen in naval service was 28½ in.

In testing for leaks use a candle in the usual way and stop the leaks with red- or white-lead putty mixed with litharge. Test for leaky tubes by filling the steam side with water under a pressure not to exceed 5 lb.

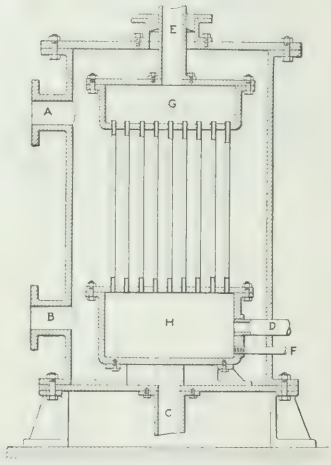
William H. Dalley.

San Francisco, Calif.

Feed Water Heater Troubles

Like Lindsay Duncan, whose letter under the above heading appears in the Apr. 16 issue, I have had considerable trouble with water heaters made somewhat after the designs shown in the illustration. Oil did not cause the trouble as in Mr. Duncan's case, but scale had completely filled the tubes connecting the chambers *G* and *H*. To clean them I had to remove the top flanges from the outer casing and drill the scale from the tubes after removing the cover from the compartment *G*.

After this process was gone through a couple of times I made a change in the heater, and instead of admitting live and exhaust steam through the inlets *A* and *B*, I connected the water inlet at *B* and



Water Heater

the outlet at *A*, with the live-steam inlet at *E* and the outlet at *D*. This change was made over a year ago and the heater still works very satisfactorily, although I was warned that this change would be a complete failure. Before it was made, the cold water entered at *D* and passed out at *E*. *F* is used for blowing out sediment. Pipes *F*, *D* and *E* are made of brass, the rest of the heater being cast iron. The large openings *A* and *B* are to be used for exhaust steam. For live steam these openings should be reduced to the desired size. Pipe *C* carries the water of condensation back to the hotwell.

John Thorn.

London Junction, Ont.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Efficiency of Electric Plant

What are the brake horsepower, the mechanical efficiency, the electrical efficiency, the steam consumption per indicated horsepower, the steam consumption per brake horsepower and the thermal efficiency of a steam-electric plant indicating 240 horsepower and delivering 150 kilowatts to the switchboard? The steam pressure is 120 pounds gage. The temperature of the feed water is 207 degrees and the steam carries 2 per cent. of moisture.

F. J. F.

$$One\ kilowatt = \frac{1000}{746} = 1.34\ e.h.p.$$

$$150\ kilowatts = 150 \times 1.34 = 201\ e.h.p.$$

There are developed in the cylinder 240 horsepower to produce 201 horsepower upon the switchboard; the "overall" efficiency is therefore

$$\frac{E.h.p.}{I.h.p.} = \frac{201}{240} = 83.75\ per\ cent.$$

This includes the mechanical efficiency of the engine and the overall efficiency of the generator. If it is assumed that the mechanical efficiency of the engine is 93 per cent., the brake horsepower will be

$$I.h.p. \times mech.\ ef. = 240 \times 0.93 = 223.2\ h.p. \qquad (a)$$

The mechanical efficiency is the ratio of the brake to the indicated horsepower.

$$\frac{B.h.p.}{I.h.p.} = \frac{223.2}{240} = 93\ per\ cent. \qquad (b)$$

as assumed. The electrical efficiency will be the ratio of the electrical horsepower to the brake horsepower

$$\frac{E.h.p.}{B.h.p.} = \frac{201}{223.2} = 90\ per\ cent. \qquad (c)$$

The electrical horsepower is the product of the indicated horsepower and the overall efficiency. The brake horsepower is the product of the indicated horsepower and the mechanical efficiency. Substituting these values in the ratio just used, thus,

$$\frac{I.h.p. \times overall\ eff.}{I.h.p. \times mech.\ eff.} = \frac{overall\ eff.}{mech.\ eff.} = \frac{83.75}{93} = 90\ per\ cent.$$

shows that the same result may be attained by dividing the overall by the mechanical efficiency. The steam consumption can be determined only by test, and the thermal efficiency cannot be computed unless this is known. Assume that the engine takes 25 pounds of steam per horsepower-hour. The heat of evaporation of steam at 120 pounds (say 135 pounds absolute) is 869.9 B.t.u., but since the quality x of the steam is but 98 per cent., that is, only 0.98 of it is in the form of steam, it will take only

$$869.9 \times 0.98 = 852.5\ B.t.u.$$

to evaporate this much. The heat of the liquid at 135 pounds is 321.7. Each pound of working fluid will carry to the cylinder

$$852.5 + 321.7 = 1174.2\ B.t.u.$$

reckoning from water at 32 degrees as a base. But the exhaust is capable of heating the feed to 212 degrees, and the engine should be credited with the 180 B.t.u. in a pound of feed water of that temperature. The net heat supplied to the engine per pound of steam is therefore

$$1174.2 - 180 = 994.2\ B.t.u.$$

and the 25 pounds per hour will bring in

$$25 \times 994.2 = 24{,}855\ B.t.u.$$

A horsepower-hour is

$$33{,}000 \times 60 = 1{,}980{,}000\ foot\text{-}pounds$$

or

$$1{,}980{,}000 \div 778 = 2545\ B.t.u.\ per\ hour.$$

To produce the equivalent of 2545 B.t.u. of work, 24,855 B.t.u. have been used. The thermal efficiency therefore is

$$\frac{Heat\ value\ of\ h.p.}{Heat\ used\ by\ engine} = \frac{2545}{24{,}855} = 10.24\ per\ cent.$$

The feed-water temperature is given as 207 instead of 212. If this figure is used, it will give a somewhat smaller efficiency; but the engine gives back steam enough and hot enough to heat its feed to 212, and if the heater does not do it or the piping radiates it, the engine is not to blame.

Effect of Clearance

What effect has clearance on the mean effective pressure?

F. W. D.

Clearance has the effect of increasing the mean effective pressure both by increasing the mean forward pressure and decreasing the mean back pressure. The steam which expands after cutoff includes that which fills the clearance spaces; hence the greater the percentage of clearance the greater the average forward pressure. On the return stroke the volume of the space into which the steam is compressed determines the compression; therefore the average back pressure will be less the greater the percentage of clearance.

Heat of Steam

Some text books give the formula of evaporation as

$$Factor = \frac{H - h}{965.7}$$

In certain correspondence school books it is given as

$$\frac{H - t + 32}{966.1}$$

H = total heat in steam at pressure of actual evaporation

t = observed temperature of feed water.

Why this difference? How would results of an evaporative test of a boiler be affected by using the latter in place of the former?

Why are the pressures in steam tables quoted as 20.3, 21.3, 22.3, etc., in place of even pounds per square inch.

G. C. U. S.

Both formulas are based on the value of the old British thermal unit, viz.: the heat required to raise 1 lb. of water 1 deg. F. from 39.1 deg. F. The second one assumes that the heat in the feed water above 32 deg. temperature increases directly with its temperature, which is not strictly true. In this and other respects the first formula is supposed, when used with certain tables, to be an improvement on the second.

The difference between using one factor or the other would be scarcely discoverable in a practical evaporative test.

The most modern steam tables (Marks and Davis) are constructed on the basis of a heat unit being $^1/_{180}$ of the heat required to raise 1 lb. of water from 32 degrees F. to 212 degrees F., and employing their values of H and h makes the formula,

$$F = \frac{H - h}{970.4}$$

As the absolute pressure of the atmosphere is 14.7 lb. per square inch (at sea level) and the ordinary gage pressure has its zero at atmospheric pressure, then any gage pressure corresponding to an absolute pressure will be 14.7 lb. per square inch less than the absolute.

Thus the absolute pressure 35.0 will correspond to

$$35.0 - 14.7 = 20.3\ lb.$$

gage pressure.

During 1911, the exports of British coal amounted to $64,599,266 long tons.

Study Questions

This Week's Questions
Last Week's Answers

21. If the uphill speed of an automobile is 15 miles an hour, the downhill speed 30 miles an hour and the speed on the level 20 miles an hour, how long will it take to go 50 miles and return over the same course?

22. What will be the inside dimensions of a completely inclosed rectangular tank made of the least possible material to hold 500 lb. of water?

23. What will be the length of a vertical wire which will break by its own weight if the tensile strength of the metal is 40,000 lb. per square inch and the weight 555 lb. per cubic foot?

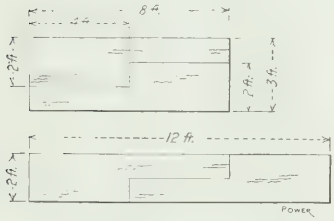
24. If a Fahrenheit thermometer indicates a rise of 45 deg., what will be the corresponding rise on a Centigrade thermometer?

25. If the displacement of a boiler feed pump is 1.25 gal. per revolution, then, allowing 20 per cent. slip, what boiler horsepower of 30 lb. water evaporated per hour will be supplied by the pump per revolution per minute?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

16. Opening one link of each piece and welding to the next would require five cuts and five welds, but the job can be done with four cuts and four welds by cutting all of the links of one 4-link piece and using these links separately to join the other five pieces.

17.



The board can be cut as shown in the upper sketch and refitted as in the lower to cover the trench.

18. At the end of its stroke the energy in the hammer will be that due to gravity plus that due to the steam pressure. That due to the weight will be

$$W \times l$$

where

W = Weight in pounds;
l = Length of stroke in feet.

That due to the steam pressure will be

$$p \times a \times l$$

where

p = Mean effective pressure;
a = Area of cylinder in square inches.

Then

$$(W \times l) + (p \times a \times l) = \textit{total energy}$$

Substituting the known values,

$$(62 \times \tfrac{8}{12}) + (90 \times 3.1416 \times (3)^2 \times \tfrac{8}{12}) = 41.333 + 1696.464 = 1737.794$$

ft.-lb.

19. The energy in the hammer at the end of the stroke is

$$E = \tfrac{1}{2} Mv^2$$

where

M = Mass of the hammer $= \frac{G}{g}$, or the weight divided by the acceleration of gravity (32.2);
v = Velocity in feet per second.

Since

G = 62 lb. and, from problem No. 18
E = 1737.794 ft.-lb.;

Substituting,

$$1737.794 = \frac{1}{2} \times \frac{62}{32.2} \times v^2$$

$$v^2 = \frac{1737.794}{0.8074} = 2152.3334;$$

$$v = 46.39 \textit{ ft. per second.}$$

20. The article "Efficiency of Joints in Boiler Shells," printed May 14, page 703, explained fully why the stress on a longitudinal seam equals half the product of the area of the longitudinal central section by the intensity of pressure. In the present problem the area referred to is

$$66 \textit{ in.} \times 16 \textit{ ft.} = 66 \times 16 \times 12 = 12{,}672 \textit{ sq.in.}$$

the pressure 90 lb. per square inch and the force tending to rupture the shell along one longitudinal seam

$$\frac{12{,}672 \times 90}{2} = 570{,}240 \textit{ lb.}$$

Errata: In the answer given to question No. 5 in the May 21 issue, the term R = radius of the sphere, used in the formula should have been D = diameter of the sphere. In the numerical substitution the diameter 6 ft. was used, not the radius 3 ft., so that the answer a = 2 ft. was correct. There was also a typographical error in the last sentence where V should have been r as was indicated by the formulas following it. The latter were wrong from having used R = 6 ft. which should have been $\frac{D}{2}$ or 3 ft. when

$$r^2 = 2Ra - a^2 = 8$$

and

$$r = \sqrt{8} = 2.83 \textit{ ft.}$$
$$2r = 5.86 \textit{ ft.}$$

Mechanical Engineers' Spring Meeting

The spring meeting of the American Society of Mechanical Engineers was inaugurated at the Chamber of Commerce, Cleveland, by addresses of welcome by His Honor the Mayor and Ambrose Swasey, chairman of the local committee. The committee on constitution submitted proposed amendments to the fundamental law, simplifying the method of electing members, providing an additional grade of membership intermediate between the junior members and the members, those composing it to be known as associate members, while those "qualified to cooperate with engineers in the advancement of professional knowledge" will be known as heretofore simply as "associates." A further amendment makes the Committee on Constitution one of the standing committees of the society.

The secretary reported a substantial increase in the membership as the result of the recent election.

Following the business meeting the professional session opened with a paper by J. Paul Clayton on "A New Analysis of the Cylinder Performance of Reciprocating Engines." By plotting the ordinary indicator diagram on logarithmic paper the pv^n curve becomes a straight line. By noting the deviations from this the various events occurring in the cylinder can be analyzed, leakage detected and the clearance figured. It also furnishes a means for calculating the steam consumption.

The other papers of the morning were "Equipment of a Modern Flour Mill on a Gradual Reduction System," by John F. Harrison and W. W. Nichols; and "The Design and Mechanical Features of the California Gold Dredge," by Robert E. Cranston.

The Thursday morning session was taken up with the presentation of four papers. The first, by Thomas D. West, upon "New Processes for Chilling and Hardening Cast Iron," outlined a series of experiments to determine the effect of different methods of treatment in chilling and hardening cast iron during the process of cooling after pouring the mold. The first experiments showing how to produce mechanically mottled and white iron inside a gray body led to experiments with chillers and with various other heat-absorbing or hardening media, such as air, charcoal, powdered manganese, cyanide, etc.

The experiments indicated that the accepted idea of chilling entirely while the molten iron is solidifying, is wrong. They showed further that the stronger grades of iron can be used for car wheels, rolls, etc., and still obtain the desired depths of chill, also that air cooling is superior to metal chillers.

The next paper, by Reid T. Stewart,

dealt with the strength of steel tubes, pipes and cylinders under internal fluid pressure. It presented the results of a series of tests and investigations into the application of the five accepted formulas, namely, Barlow's, Lamé's, Clavarino's, Birnie's and the common formula $\left(t = \frac{pD}{2f}\right)$. . These showed that Clavarino's formula is theoretically correct for cylinders with attached heads and Birnie's formula for heads held independently. These formulas are practically applicable to certain classes of seamless-steel tubing and to a critical examination of ordinary commercial steel tubing when accurate data are available.

In commercial welded pipe the variation in the thickness of the walls, perfection of the weld, etc., account for a variation in the bursting strength sufficient to render unnecessary any consideration of Clavarino's or Birnie's condition of head support. For ordinary commercial wrought-iron pipe Barlow's formula is recommended. This is

$$\frac{p}{f} = 2\frac{t}{D}; p = 2f\frac{t}{D}; t = \frac{1}{2}D\frac{p}{f}; f = \frac{1}{2}D\frac{p}{t}$$

where

D = Outside diameter in inches;
t = Average wall thickness in inches;
p = Internal fluid pressure in pounds per square inch;
n = Factor of safety;
f = Fiber stress in pounds per square inch;
$= \frac{40{,}000}{n}$ for butt-welded steel pipe;
$= \frac{50{,}000}{n}$ for lap-welded steel pipe;
$= \frac{60{,}000}{n}$ for seamless steel tubes;
$= \frac{28{,}000}{n}$ for wrought-iron pipe.

Next came Prof. William F. Durand's paper on the "Control of Surges in Water Conduits." This dealt with the design of surge chambers having a tapering rather than a cylindrical form and embodied the development of a method by which the approximations of the various analytical and empirical formulas may be avoided and a chamber determined with a taper to suit the given conditions.

The final paper of the morning was by William Uhl upon the "Speed Regulation in Hydro-electric Plants." This, like Prof. Durand's paper, was of a highly technical nature and elicited practically no discussion.

The program for Friday morning included four papers: "The Present State of Development of Large Steam Turbines," by Prof. A. G. Christie; "A Discussion of Certain Thermal Properties of Steam," by G. A. Goodenough; "The Reduction in Temperature of Condensing Water Reservoirs Due to the Cooling Effect of Air and Evaporation," by W. B. Ruggles, and "The Results of Tests on the Discharge Capacity of Safety Valves," by E. F. Miller and A. B. Carhart.

The first dealt with the construction details of the leading types of large steam turbines, the commercial results obtained and the present tendencies in development. Owing to the importance of the subject, considerable discussion was evoked. An extract from this paper appears on page 831 and an abstract of the remainder of the paper will be printed in a latter issue.

In the absence of Mr. Ruggles, his paper was presented by F. E. Cardullo. This paper was based on the data obtained from tests on a cooling reservoir of about 6½ acres, the object being to determine from the heat radiation a reliable factor for use in determining the size of reservoir for any assumed conditions. The tests were made in May, July and November of last year and were each of a week's duration; the plant was of about 2500 hp. The average temperature of the reservoir was taken as the difference between the average inlet and outlet temperatures and the difference between this and the average air temperature as the temperature difference between the air and water. With these assumptions the heat absorbed by the air and by evaporation was found to be from 3.22 to 3.71 B.t.u. per square foot of surface per degree temperature difference.

In the discussion following, Mr. Cardullo criticized the method of arriving at the average temperature of the reservoir, claiming that the arithmetrical mean does not represent the average temperature, but rather, that it is more nearly the intake temperature, as the greatest evaporation occurs at that point. He also believed that Mr. Ruggles had erred in neglecting to consider wind conditions. From his experience, 3½ to 4 B.t.u. per square foot of surface per hour per degree difference of temperature was a factor close enough for all ordinary purposes.

The last paper of the morning, "The Results of Tests on the Discharge Capacity of Safety Valves," has already been printed in abstract (see POWER, Mar. 5, 1912, page 323).

Gas Power Section

In the absence of the permanent chairman, F. R. Low presided, and in opening the session referred to the loss sustained by the gas-power section through the death of one of its most active members, F. H. Stillman.

The first paper, by Thomas R. Weymouth, dealt with problems in natural-gas engineering. It included a discussion of the properties of natural gas, supplemented by a table of analyses of gases produced in the principal gas fields of the United States. For use where analyses or a calorimetric determination of the heat value are not available, a formula was submitted for arriving at the heat value of a gas from its specific gravity, with very close approximation. The second part of the paper was devoted to the development of original formulas for the flow of gas in pipe lines, the power required for compression and the storage capacity of lines. This was further supplemented by examples showing the general method of designing a transmission system.

Prof. G. W. Munro's paper, "Some Tests of Carburetors," outlined the problem of carburation for motor vehicles and pointed out the difficulties met in determining the performance of a carburetor as distinct from the performance of the engine. The paper contained the results of some 400 economy tests on a single engine served by six different carburetors under identical conditions of speed and load. These tests lead to the following conclusions:

1. Under identical conditions of speed and load an engine gives materially different fuel economy when served by different carburetors.

2. Carburetor action is the limiting factor in engine capacity as well as in economy.

3. Each carburetor has distinctive performance characteristics which may be determined and plotted.

4. Wide range and perfect operation give no indication of fuel economy.

5. A carburetor giving excellent results under some conditions may give very poor economy over a large part of its range.

In the discussion, it was generally conceded that, although the tests were too limited to afford a definite basis for conclusions, Professor Munro had taken the lead in a field of investigation which might be followed up with very productive results. While the engineering staffs of many automobile manufacturers have given much time and attention to this problem and have obtained very good results, generally each has been concerned with a particular make of engine, therefore the problem has not been treated as broadly as it might otherwise have been.

The point was also brought up that atmospheric conditions factor largely in the adjustment and operation of a carburetor.

George A. Orrok remarked that Professor Munro had failed to take advantage of some of the more improved types of carburetors and believed that more conclusive results might have been obtained with those having an auxiliary air valve.

Fred S. King, of the National Meter Co., said that his experience with the larger gas engines had been that the size of cylinders had a great influence upon the mixture.

The last paper at this session, by C. M. Garland, concerned bituminous-coal gas producers. It described the general arrangement of bituminous producers as designed for power, gave details of the scrubbing apparatus, data as to its efficiency and the amount of solid matter delivered. Figures for the first and operating costs at full load for a 1200-hp. plant were given so as to make them applicable to different conditions of fuel and load.

A fuller abstract of this paper will be given in a later issue.

Social Program

Much credit is due the local committee for the very complete arrangements covering the entertainment of members and guests. Beginning with a reception by Past President and Mrs. Swasey on Tuesday afternoon, a reunion of members followed in the evening at the Chamber of Commerce Hall.

a dance and reception was given at the Colonial Club.

Excursions to the plants of the Goodrich Rubber Co. and the Wellman-Seaver-Morgan Co., at Akron, on Friday afternoon, concluded the social program.

New Jersey N. A. S. E. Convention

The New Jersey State Association of the National Association of Steam Engineers held its annual convention at Krueger Auditorium, Newark, N. J., from May 30 to June 2.

The exhibition was opened on May 30 and was well attended. The convention opened at 2 p.m., Saturday, June 1, followed by a banquet in the evening.

J. H. Donnelly, President of the Common Council of Newark, delivered the welcoming address as Mayor Jacob Hausling was unavoidably detained. Edward H. Kearney, National President, stimulate action to betterment in operating practice. Alderman M. J. McGovern, Jr., also spoke on the value of intelligent coöperation. Curtiss R. Burnett, president of the Board of Trade, spoke of Newark's industrial growth. He quoted from statistics which showed that 252 different commodities were made in Newark and that last year's output amounted to $219,000,000. Good singers and humorists furnished enjoyable entertainment.

The Exhibit

The exhibit was unquestionably the most successful ever held in New Jersey. There were many booths containing power-plant requirements of all conceivable kinds. The firms represented were as follows: Albany Grease Co., Ashton Valve Co., American Engine Co., A. B. Botfield Co., American Oil & Supply Co., A. C. Lippincott S. S. & Supply Co., Boig & Hill, Buhne Metal Packing Co., Cran-

New Jersey N. A. S. E. Banquet, at Krueger Auditorium, Newark, N. J.

While the professional session was in progress Wednesday morning, the ladies were taken on an excursion to the plant of H. Black & Co., cloak manufacturers. Luncheon was served by the society and in the afternoon parties visited the plants of the American Steel & Wire Co., the Brown Hoisting Machinery Co., the National Acme Manufacturing Co., the Peerless Motor Car Co., the Pennsylvania R.R. Co.'s ore-handling plant, the Warner & Swasey Co., the Winton Motor Car Co. and the White Co. In addition to these numerous other plants within the city extended the courtesy of inspection to the visitors.

After the trips, tea was served at the Country Club. In the evening a very interesting lecture on sound was given by Dr. Dayton C. Miller, of the Case School of Applied Science.

Thursday afternoon a boat ride was enjoyed on Lake Erie and in the evening told of the progress of the association, saying, in part, that the first national convention was held 29 years ago in a small room in Past President Beckerleg's house. The present convention was great in contrast as the city's largest hall was crowded. Judge Robert Cary, of the Supreme Court of Hudson County, gave a most interesting talk on the importance of the engineer in civic life and requested them to take a more active part in engineering political affairs to a better condition.

Past National President William Reynolds spoke of the value of coöperation, and Fred R. Low, editor of Power, talked on the educational opportunities open to engineers which, if taken advantage of, would lead to still higher standing of the vocation. George W. Knight, chief engineer of public schools, read a paper on efficiency and its relation to the operating engineer. Mr. Knight's purpose was to

dall Packing Co., Cooney & O'Rouke, Clement Restein Co., Crane & Milligan, C. T. Coe & Co., Crane Co., Couse & Bolton, C. E. Squires Co., Consolidated Packing Co., Cling Surface Co., Dayton Belting Co., Dearborn Drug & Chemical Works, David C. Seymour Co., Dixon Cascade Pump Co., Eureka Packing Co., Foster Engineering Co., Fletcher, Stanley Co., F. W. Webb Manufacturing Co., Griscom, Spencer Co., Greene, Tweed & Co., Garlock Packing Co., General Electric Co., Greenpoint Fire Brick Co., Home Rubber Co., H. W. Johns-Manville Co., H. B. Underwood & Co., Homestead Valve Manufacturing Co., Hewes & Phillips Iron Works, Heine Safety Boiler Co., International Acheson Graphite Co., Iron Works Co., International Correspondence Schools, Jenkins Brothers, Jackson Awning Co., James W. Crane, John A. Roebling Sons' Co., Keystone Lubricating Co., Lunkenheimer Co., L. J.

Wing Manufacturing Co., Ludlow & Squires, Manning, Maxwell & Moore, M. T. Davidson Co., Macknet & Doremus Co., McLeod & Henry Co., Mutual Supply Co., N. Y. Belting & Packing Co., Norbin Oil & Supply Co., National Flue Cleaner Co., National Oil & Supply Co., Newark Fire Alarm Co., Otis Elevator Co., Ohio Blower Co., Peerless Rubber Manufacturing Co., Pitts & Kitts Co., POWER, Philadelphia Grease Co., R. & J. Dick Co., Ross & Taggart, Standard Regulator Co., Strong Machinery Co., Sunset Co., Schaeffer & Budenberg Manufacturing Co., Smooth-On Manufacturing Co., Strong, Carlisle & Hammond Co., Simmons Pipe Bending Works, Standard Oil Co., the Under-Feed Stoker Co. of America, V. D. Anderson Co., Walter G. Ruggles Co., Warren Webster & Co., W. B. McVicker Co., William Powell Co., Yingling & Sons.

Gas Engine Association Convention

During the semiannual convention of the National Gas Engine Association, to be held at Milwaukee on June 17 to 22 in conjunction with the gas-engine show, the following program will be presented:

On Tuesday, June 18, the gas-engine manufacturers' section (composed of members who are manufacturers of gas or gasoline engines of any kind) will discuss freight rates on gas and gasoline engines, considering their weight, the way they are packed and the small liability of breakage.

Charles Barnes, Kenosha, Wis., an attorney who has made inspection a particular study, will present this question: "Is the present system of oil inspection of any particular value, and if so, what?"

This question will also come up for discussion: "Are we satisfied with the present insurance rates issued by the Board of Underwriters? If not, will concerted action on the part of the engine builders throughout the country bring about a radical change to the benefit of our business?"

The advisability of a standard form of guarantee, to be known as the Association Standard Guarantee, will be considered during this session.

On Wednesday, June 19, the main sessions of the association will include these papers: "Lubrication and What It Means," A. E. Potter, New York; "Oil Engines," A. O. Krieger, St. Louis; "Gas Engines for the City," H. W. Jones, Chicago; "Gas Producers."

On Thursday, June 20 (Farm-Power Day): "Storage Battery in Isolated Lighting Plants," Taliaferro Milton; "Generators," C. H. Roth, Chicago; "The Tractor," L. W. Ellis, La Porte, Ind.; "How Can the Dealer Best Increase His Sales?" Open discussion, led by President Parker; "Essentials of Foreign Sales Development," Franklin Johnston, New York.

Friday, June 21 (Publicity Day): "Publicity Through the Trade Journals and What It Means to the Manufacturer," E. R. Shaw, president Federation of American Trade Press Associations; "Publicity Through the Trade Journals," W. R. C. Smith, Atlanta, Ga.; "Direct Advertising to the Dealer," C. H. Hall, Milwaukee; "General Publicity," F. E. Long, Chicago.

H. E. Miles, chairman of the committee on industrial education of the National Association of Manufacturers, will also deliver an address during the convention.

Tickets of admission to the convention and the entertainments will be secured from the exhibitors or members. When presented by the recipient he will receive a numbered badge entitling him to admission to the convention sessions (except executive meetings) and to the entertainment provided by the local committees. Every provision will be made for the comfort and entertainment of persons associated with the trade in any way or who are interested in the subject of gas-engine power, and special provision will be made that such persons be admitted to the convention during the open sessions.

Ladies' Auxiliary N. A. S. E. Convention

On May 22, the Ladies' Auxiliary of the New England Association of Stationary Engineers held its twelfth annual convention at the Benedict House, Pawtucket, R. I. Forty-five delegates, representing auxiliaries throughout New England, were in attendance. The convention had as guests National President Edward F. Kearney and Mrs. Kearney, Boston; Past National President Herbert E. Stone, Framingham, Mass.; Past National President Mrs. Nellie Moore, of the Ladies' Auxiliary, Worcester, Mass.; National Treasurer Mrs. Emma Stone, Framingham, Mass.

A revision of the bylaws was discussed and a resolution adopted petitioning the national convention for the privilege of a referendum vote of the subordinate body. It was voted to hold the thirteenth annual convention in Waterbury, Conn. The reports of the condition of the affiliating auxiliaries showed progress during the year, with one new auxiliary formed in Torrington, Conn., and one organized at New Bedford, Mass.

Officers were elected as follows: Past President, Mrs. Ollie Heckler, New Haven, Conn.; president, Mrs. E. C. Greene, Chartley, Mass.; vice-president, Mrs. Gertrude Hunt, Hyde Park, Mass.; recording secretary, Mrs. Dorothy Cole Rowe, Waltham, Mass.; treasurer, Mrs. Hannah L. Canfield, Providence, R. I.; conductor, Mrs. Nettie Pike, Worcester, Mass.; chaplain, Mrs. Nellie E. Travers, New Bedford, Mass.; doorkeeper, Mrs. Minnie T. Hallm, Springfield, Mass.

The delegates were guests of the local branch at a reception in the evening.

"Carpathia's" Crew Honored

On the arrival of the "Carpathia" in New York on May 29 from Naples, she was boarded by a committee of "Titanic" survivors bearing a loving cup and gold medal for Capt. Arthur H. Rostron and silver and bronze medals for his officers and crew.

Chairman Frederick K. Seward headed the committee and the presentation took place in the "Carpathia" dining room, where were assembled the entire ship's company.

Having feelingly thanked the committee for the loving cup and medal, Capt. Rostron said: "I will not take the credit for the achievement of that night when we went to the aid of the people of the 'Titanic.' I do not deserve this credit. My crew does, and to them I want to give my heartfelt thanks for their loyalty, valor and fidelity to the trust imposed. I cannot think of them too highly, for they have brought this honor to me and to themselves, and I feel humbly proud of what has been done for me through their valor."

Chairman Seward then spoke to the crew, saying, in part: "The eyes of the world are upon you and were upon you when you came to us on the open ocean, when we saw the 'Carpathia' coming to us out of the dawn. To all of you we wish to give our heartfelt thanks. For your hospitality, devotion, unselfishness and for all that was done for us we never can be adequately grateful, and as a slight token of that appreciation we wish you to accept the medals that we have had struck for every man and woman of this ship."

The medals bore in bas-relief a copy of the "Carpathia" going at full speed to the rescue of the "Titanic's" victims, while the reverse side bore the following:

"Presented to the Captain and crew of the R.M.S. 'Carpathia' in recognition of their gallant and heroic services, from the survivors of the S.S. 'Titanic,' April 15, 1912."

There were six gold medals, one for Capt. Rostron, Chief Engineer Johnson, Surgeon Frank E. McGee, Purser E. G. F. Brown, R. N. R.; Chief Steward E. H. Hughes and Second Engineer Marshall. Then, at the request of the committee, Capt. Rostron handed a medal to each member of the crew as they responded to their names called by Purser Brown, each man saluting the commander as he received his decoration, while his ship-

mates cheered. The junior officers received silver medals and the crew bronze.

In speaking of the honor that had been accorded to him by the United States Government, Capt. Rostron said that he was proud for himself, the officers and the crew of the "Carpathia," and for the Cunard Line, and that he believed the whole mercantile marine of the world would feel honored by it.

Cylinder Head Blown Out

The cylinder head of one of the large horizontal engines at the plant of Hahne & Co.'s department store at Newark, N. J., was blown out on Wednesday, May 29. The jam nut which held the piston became loose and dropped from the rod, causing the head to be blown out on the return stroke. The condensed steam damaged the stock adjacent to the engine room.

Boiler and Flywheel Accidents

According to the May bulletin of the Fidelity & Casualty Co., of New York City, from Mar. 8 to Apr. 13 there were 25 boiler explosions, and from Mar. 28 to Apr. 11, four flywheel explosions.

There were 47 persons killed and 81 injured by boiler explosions, and one person was killed and two injured in the flywheel accidents.

NEW PUBLICATION

MECHANICS OF HEATING AND VENTILATION. By Konrad Meier. McGraw-Hill Book Co., New York City. Cloth; 161 pages, 6x9 in.; 36 illustrations, 10 charts. Price, $5.

As its name implies this book is a treatise on the flow and resistance of fluids as applied to the practice of heating and ventilation. Especially noteworthy are the charts showing capacities and friction losses of standard iron pipes for steam and water under different conditions, and capacity and losses for sheet-iron air ducts. The arrangement of the charts is excellent for convenient, rapid and practical use. For accurate results much will depend upon the judgment of the engineer in making the proper assumptions, but a careful study of the text matter and the formulas upon which the charts are based will help in this direction.

The book treats air, water and steam as fluids governed by the same laws as applied to the design of conduits for their conveyance. This should have a decided influence in clearing up many erroneous ideas that are abroad concerning the action of steam as applied to heating at pressures below atmosphere. A thorough study of the charts and text and the solution of a few problems in pipe sizes will show the limitations in the use of steam for heating at pressures below atmosphere.

In designing systems of piping the author lays great stress on the importance of balancing the friction heads so as to equalize the flow, and the examples furnished show this done with considerable refinement. Nothing is said about arranging the piping so as to balance the distance as well. This is exceedingly important when high heads and long distances are involved as in forced circulation of hot water, while not so necessary when low heads and short distances occur as in house-heating work.

The author makes the point that individual regulation of branches by means of choke valves is unnecessary where the distributing system has been properly sized, and the work is an able demonstration of the engineering fact that even the worst layout of piping can be properly balanced in discharge by use of the tables and charts.

On page 31 the relation of the static head of the system with reference to the height of the expansion tank is mentioned. On large jobs the tank should be connected to the return and operated with air pressure of 15 lb. in addition to the static heads of the system. Better results will be obtained and the difficulty of a vacuum forming on the return of the pump will be avoided. The overhead tank at a remote point will always endanger the piping due to the fact that leaks are not easily discerned when an automatic water feeder is used. This is not so important on small plants.

The charts on gravity water circulation are excellent and very convenient for use. They undoubtedly have been verified by the author in his extensive experience in this line of work.

In the derivation formulas for chart III a slight arithmetical error creeps in. The quantity 83.8 H should be 83.7 H and for chart II the same quantity 70.8 H should be 70.4 H. These errors do not materially affect the results.

Recommendations to bring the resistance head to within 10 per cent. of the available effective head are made on page 45. Although this might be done with good results on jobs with low velocity, it is too close for high velocities, due to the charts not covering all known conditions of a piping system as finally installed. On page 73 the author suggests that reducing valves may be eliminated on long lines and the drop in pressure made available for high velocities and very small pipe sizes, in this manner balancing the radiation of the system of distributing mains with the heat generated by friction. This is entirely practical, although making the use of very low pressure impossible as required when exhaust steam is to be utilized.

Chart VII recommends 6 to 12 lb. per square foot for the drop in pressure on the entire system. This will give altogether too large a main as in most cases the total drop can be easily 100 or 144 lb. per square foot, as this would only mean ⅔ or 1 lb. pressure per square inch. The radiation from the larger main would be a more serious item of loss than the drop in pressure, to say nothing of the extra cost of larger mains and covering.

The chart and chapters on the flow of air and losses in friction in ducts are good and the values given check almost exactly with independent authorities. This chart is invaluable in arranging duct work and should have a decided influence in increasing the economy of operation over the present method of guessing and using adjustable dampers in the branches.

Mr. Meier deserves to be congratulated for his practical and useful contribution to the profession. The charts are exceedingly valuable as a guide in laying out classes of work for which the author intended them and the data given enable modifications to be made by the engineer to suit his individual conditions. They should pay a handsome return in decreased trouble in adjustment due to uncertain design.

PERSONAL

F. C. Buckley has succeeded Robert R. Keith as general manager of the Sterling Machine Co., of Norwich, Conn.

William McClellan, electrical engineer of the New York Public Service Commission, Second District, was elected a manager for a term of three years at the annual meeting of the American Institute of Electrical Engineers on May 21.

A. B. Hitzel, for several months manager of the Bernardsville, N. J., power plant for the Eastern Pennsylvania Power Co., has resigned to accept the position of general manager for the Carolina Power & Light Co. Mr. Hitzel will be succeeded by E. E. Yensel, of Scranton, Penn.

Of the 17 steel-hull steamers and 12 steel barges being built by the James Rees & Sons Co., of Pittsburg, for the Para Corporation, of South America, eight of the steamers have been erected and all will likely be finished by Aug. 1. The vessels, designed for light-draft work on the headwaters of the Para and Amazon Rivers, are of the stern-wheel type, 125 ft. long, 26-ft. beam and 3-ft. hold. They will draw 17 in. light, have a carrying capacity of 150 tons, and be driven by a pair of 9-in. cylinders with 4-ft. stroke. The boilers will be of the locomotive type, arranged for wood burning, to conform with the conditions of the country in which they are to be operated. The barges are 18x75 ft. and can be loaded to a depth of three feet.

POWER

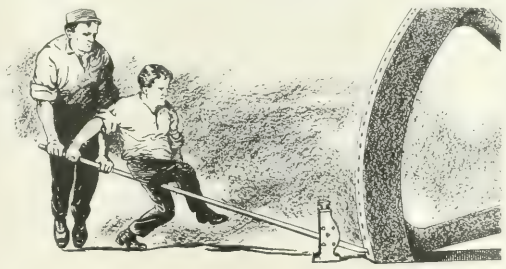
Vol. 35 NEW YORK, JUNE 18, 1912 No. 25

The Helpful Paper

WHEN a large engine is to be turned by hand, the engine room force concentrate their efforts in one direction. Were they to pull against one another from opposite sides of the flywheel, nothing would be accomplished. This is typical of any purpose; if there is to be any good done, there must be harmony of effort.

"Power" is devoted to the generation and transmission of power, especially the practical and operating considerations, and its aim is to assist the owner, the manager and the engineer. Its success is dependent in great measure on the hearty co-operation of its more than 30,000 readers acting through the editorial staff. It's like turning the engine over: **A long pull, a strong pull and a pull all together.**

Sometimes a well intentioned member wants to pull the other way without due consideration for his colleagues. He wants the paper to embrace deeper and more technical subjects while another implores that such matter be tabooed. If either had his entire way it would result in an unbalanced load, so to speak, so the editors have to act as the equalizer.



The operating engineer wants material telling him how to run his plant properly without going into mathematics or dealing with things with which he is unfamiliar. He wants plain practical matter readily applicable to his needs. He gets it, and he's going to continue to get it.

Still, the man who wants more advanced information must not be forgotten. It is "Power's" function to cover the whole field of power generation and transmission. There are abstruse problems in which the advanced thinkers in the field are interested. The rate of progress and the comparative achievement of different plants and apparatus are marked by tests the analysis of which may carry the untaught reader over his head. He should not begrudge the space devoted to these subjects, any more than the "highbrow" who can read them should turn up his nose at the more elementary matter. There is more than 4 cents' worth in every issue for every man who will read it.

The phenomenal advance in power plant engineering in recent years has thrown upon the engineer increased duties of a wider and more varied character. To successfully meet the new conditions requires a wider and more varied knowledge. This brings before the engineer many unfamiliar problems and appliances that he is at first apt to consider beyond him. It is "Power's" purpose to tell him about these things, to keep him in touch with the development in his vocation. To shun these important matters would be to cease to be thoroughly practical, to cease to be the leader; hence "Power" must not fail to inform of uptodate practice.

To half tell a thing is worse than not telling it at all. But to tell it all, and tell it in comprehensible language—so you can read it—that is what you want. That is "Power's" plan.

So let us exert an even longer pull, a stronger pull and a pull altogether.

A New Analysis of Indicator Cards

Adapted from a paper by the originator of the analysis, J. Paul Clayton.

Describes means for determining from an indicator diagram an almost complete analysis of the cylinder performance of a reciprocating engine, including results heretofore considered impossible to so obtain accurately.

If when fluid expands, as does steam in the cylinder of an engine, its pressure varies inversely as its volume, the relation of pressures and volumes will be represented by the middle curve in Fig. 1. The product of the volumes and the pressures corresponding with the several volumes will be as follows:

Vol.	×	pressure	= constant
1	×	120	= 120
2	×	60	= 120
3	×	40	= 120
4	×	30	= 120
5	×	24	= 120
6	×	20	= 120

Setting these pressures off upon the corresponding ordinates and connecting the points so located, the curve is formed as shown.

Suppose, however, that the variation of pressure with change of volume were such that the product of the pressure and the *square* of the volume were constant. The pressures for the several volumes would be as follows:

Vol.	Vol.^{2}	× pres.	= constant
1	1	× 120	= 120
2	4	× 30	= 120
3	9	× 13⅓	= 120
4	16	× 7½	= 120
5	25	× 4.8	= 120
6	36	× 3⅓	= 120

Setting these values of the pressure off upon the several ordinates, the curve drawn through them is the lower one of Fig. 1.

Suppose, again, that the product of the pressure and the *square root* of the volume were constant, the pressures for the several volumes would be as follows:

Vol.	$\sqrt{\text{Vol.}}$	× pres.	= constant
1	1	× 120	= 120
2	1.414	× 84.85	= 120
3	1.732	× 69.28	= 120
4	2	× 60	= 120
5	2.236	× 53.66	= 120
6	2.449	× 49	= 120

The expression $4^{\frac{3}{2}}$ means that 4 is to be raised to the third power, or cubed, and that the second or square root of that power is to be extracted. Similarly $4^{\frac{1}{2}}$ means that the second or square root of the first power of 4 is to be extracted. As the first power is the quantity itself, this is a convenient way to express the square root of a quantity. The small figure above the number is called the "exponent" and when fractional it may be expressed as well by a decimal as a vulgar fraction thus:

$$4^{\frac{1}{2}} = 4^{0.5} = 2$$

In Fig. 1 it will be seen that if this exponent is less than unity, the curve will be above the $pv = con.$ curve with which the expansion and compression lines of the steam-engine indicator are commonly compared, while if it is greater than unity, the curve will be below that in plotting which the exponent of v is taken as unity, and a variation of the value of the exponent between 0.5 and 2 will carry the curve from the upper to the lower position in Fig. 1.

J. Paul Clayton, of the engineering-experimental station of the University of Illinois, in a remarkable paper presented at the spring meeting of the American Society of Mechanical Engineers, describes a new method of analyzing the indicator diagram which is full of interest and promise. From the study of a large number of diagrams from engines of various types and running under different conditions, he found that the expansion and compression lines were quite generally true exponential curves, such as would be derived by the formula

$$pv^n = con.$$

but that the value of the exponent n varies between 0.7 and 1.34, the curve ordinarily used being simply the special case where $n = 1$ and $pv = con.$

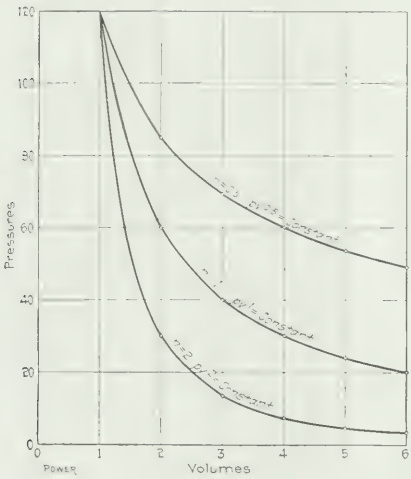


FIG. 1. *pv* EQUATIONS PLOTTED WITH REGULAR CO-ORDINATES

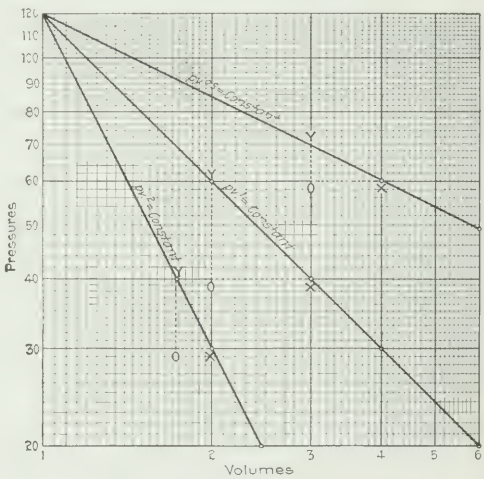


FIG. 2. SAME EQUATIONS PLOTTED WITH LOGARITHMIC CO-ORDINATES

If the ordinates, instead of being spaced equally as in Fig. 1, are spaced like the spaces on a slide-rule, so that the space from 1 to 2 equals the space from 2 to 4 or from 4 to 8, and the heights corresponding to the pressures are laid off in the same way, a curve having the formula

$$pv^n = con.$$

will become a straight line when laid out upon such a field. Paper ruled in this way and called logarithmic cross-section paper can be had from a dealer in draftsman's supplies.

A sample with the curves of Fig. 1 laid out upon it is shown in Fig. 2. The pitch or inclination of the curves (now become straight lines) depends upon their exponent, and the exponent may be de-

termined by drawing a vertical and horizontal line intersecting each other and the curve as in Fig. 2, and dividing the length of the line OX by that of the line OY. Notice that for the middle curve OX is the same as OY and

$$\frac{OX}{OY} = 1$$

On the lower curve OX is only one-half as long as OY and

$$\frac{OY}{OX} = 2$$

while for the upper curve OX is twice as long as OY and

$$\frac{OY}{OX} = 0.5$$

indicating thus the exponents used in the formulas by which the curves were laid out.

Mr. Clayton plots not only the expansion and compression curves but the whole diagram upon logarithmic paper, and the diagram so produced offers many important advantages for analysis.

Transferring the Diagram

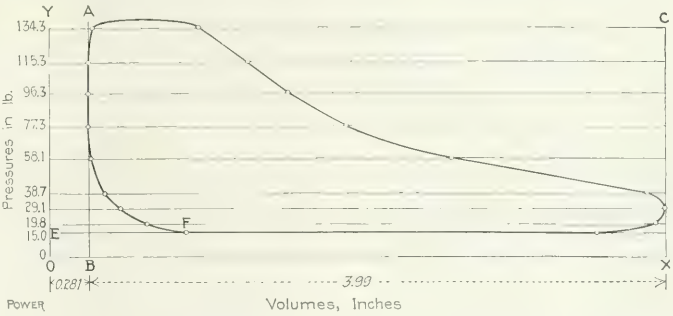
Fig. 3 shows a diagram from a Corliss engine transferred in this way. It must be prepared by putting on the line OX, representing the absolute zero of pressures, and the line OY, representing the absolute zero of volumes. The distance between the line OX and the atmospheric line must be the barometric pressure at the place and time that the diagram was taken measured by the scale of the indicator spring used. The distance between the line OY and the line AB, marking the extreme left of the diagram, must bear the same proportion to the length AC of the diagram that the volume of the clearance bears to the piston displacement. In this engine the clearance is 7.04 per cent. The length AC of the diagram is 3.99 in. The width YA of the clearance space on the diagram is therefore

$$0.0704 \times 3.99 = 0.281 \text{ in.}$$

The barometer reading when the diagram was taken was 14.2 lb. per square inch and the scale of the spring used in the indicator was 79. The distance between the atmospheric and absolute zero lines is therefore

$$14.2 \div 79 = 0.18 \text{ in.}$$

The logarithmic paper used consists of four 5-in. squares arranged two each way, as in Fig. 3, which shows the lower left-hand square complete with portions of the others. As the paper comes from the dealers it is numbered by heavy figures close to the ruling. These have been multiplied by 10 to



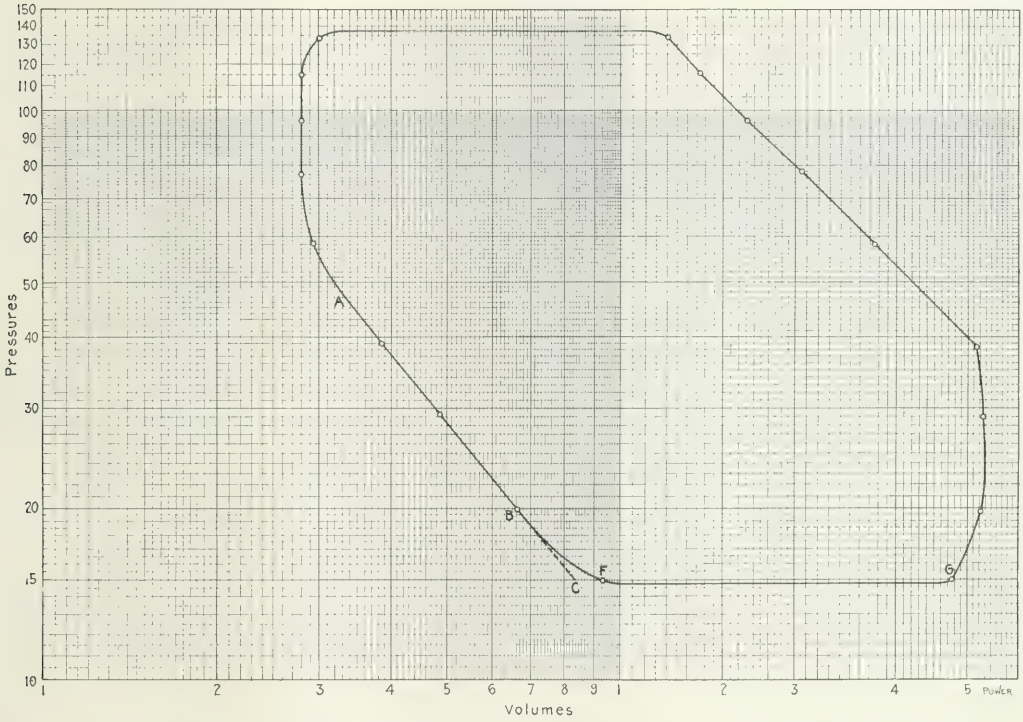


Fig. 3. Diagram from Corliss Engine Transposed to Logarithmic Scale

give the scale of pressures as indicated by the figures at the left.

The horizontal scale, that of volumes, will do as it is. The printed figures below the lower left-hand square will represent tenths of an inch and the intermediate rulings hundredths, except in the extreme left-hand division, 1 to 2, where there are 20 subdivisions of one-half a hundredth each. The figures in the right-hand square represent even inches.

A number of horizontal lines may be drawn across the diagram, as shown, and their intersections with the diagram transferred to the logarithmic paper. The point *F*, for instance, is at a height corresponding to 15 lb., and its distance *EF* from the zero or clearance line is 0.93 in. The point is thus located on the ordinate 0.93 on the scale of volumes (indicated by *f* on the horizontal scale) at the intersection of the horizontal line indicating 15 lb. At the same height but at the horizontal distance 3.77 is located the point *G*.

and one wonders how the professor read to tenths of pounds with a 79-lb. scale, but small differences in the pressures would have little effect upon the location of the points, especially in the upper part of the diagram.

Location of Points of Cutoff Compression, Etc.

The point of cutoff can be located on the ordinary indicator diagram to within $\frac{1}{16}$ in., measured on the diagram itself. The actual beginning of true compression, however, can never be accurately located on such a diagram. True compression, unaffected by leakage, begins after the exhaust valve, in closing, has acquired enough seal to prevent leakage. The point of the beginning of true compression is generally at least 5 lb. above the

the logarithmic diagram. Prof. Clayton says that these events, even though obscure in the pressure-volume diagram, may be located to well within about $\frac{1}{16}$ in. on the logarithmic diagram, this length being equivalent to about $\frac{1}{32}$ in. when retransferred to the *pv* diagram itself.

In most of the diagrams given in the paper the horizontal distances are taken as volumes in cubic feet, instead of lengths on the diagram. The author computes the volume of the cylinder for 1-in. length of diagram and multiplies the distance of the points from the line of zero volume by this factor. When the horizontal scale is used as diagram lengths the location of points determined as in the foregoing may be set off directly on the *pv* diagram at the intersection of the same pressure and volume lines, revers-

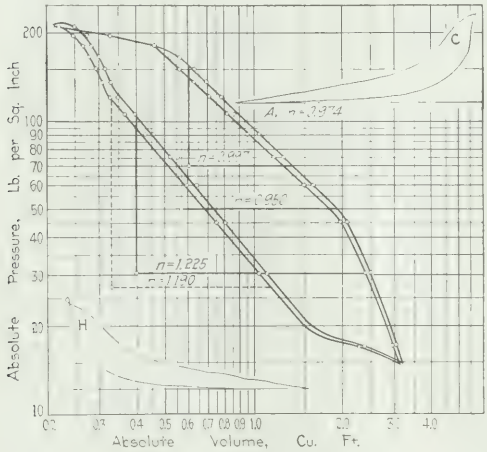


Fig. 4. Diagrams from Locomotive Using Superheated Steam

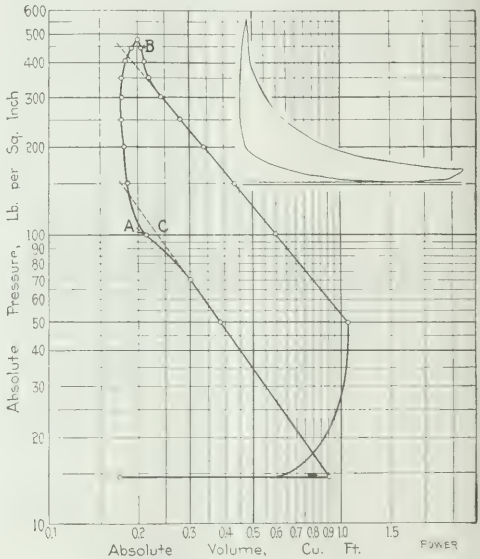


Fig. 5. Diagrams from Gas Engine Using Illuminating Gas

In this way the several points of the indicator diagram are transferred to the logarithmic paper and lines drawn through them furnish the logarithmic diagram. The values of the pressures and volumes used in the diagram as given by Prof. Clayton are as follows:

Abs. pressure, lb. per sq.in.	Distance from zero volume line of points on Compression line	Expansion line
134.3	0.30	1.205
115.3	0.28	1.39
96.3	0.28	1.65
77.3	0.28	2.06
58.1	0.295	2.76
38.7	0.385	4.12
29.1	0.485	4.26
19.8	0.66	4.29
15.0	0.93	3.77

There is no reason why the spacings should not be located at even pressures,

back pressure. The point at which leakage ceases cannot be indicated upon the pressure-volume or ordinary indicator diagram because the curve of true compression and the curve made during the time the valve has insufficient seal are of the same direction of curvature, and are not reverse curves as in the general case of admission and expansion.

The law $pv^n = con.$ will apply only when the weight of fluid operating is constant. The compression or expansion line of the logarithmic diagram does not become straight until this condition has been established.

In Fig. 4 are shown diagrams from a locomotive taken at short cutoff and high speed. In their form as they came from the indicator the points of cutoff release compression and admission are very difficult to locate, but stand out sharply in

ing the process by which Fig. 3 was plotted. When the horizontal scale is used for specific volumes, as in Fig. 4 and others from the paper, the reading for volume must be divided by the volume per inch of cylinder to obtain the horizontal distance on the *pv* diagram. The shape of the diagram will be the same whichever value is used for the horizontal scale; it will simply be shifted horizontally on the paper.

Detecting Leakage

It has been pointed out that the expansion and compression curves will become straight lines in the logarithmic diagram only when the weight of fluid acting remains constant. They will not be straight lines, therefore, when the quantity of fluid acting is being changed by leakage into or out of the cylinder.

Except in the highly improbable case, where the leakage into just replenishes the leakage out of the cylinder, the effect of leakage will be to distort the expansion and compression curves so that they do not become straight lines on the logarithmic diagram.

Fig. 5 is a diagram from a 10x10-in. gas engine intended for producer gas but using illuminating gas, which, with the high compression, produced a high initial pressure. The piston, a single-acting trunk type, allowed a large leak, evidenced by the noise of escaping gas at the commencement of the combustion stroke. Both the compression and the expansion curves show the effect of this leak very decidedly at *A* and *B* respectively.

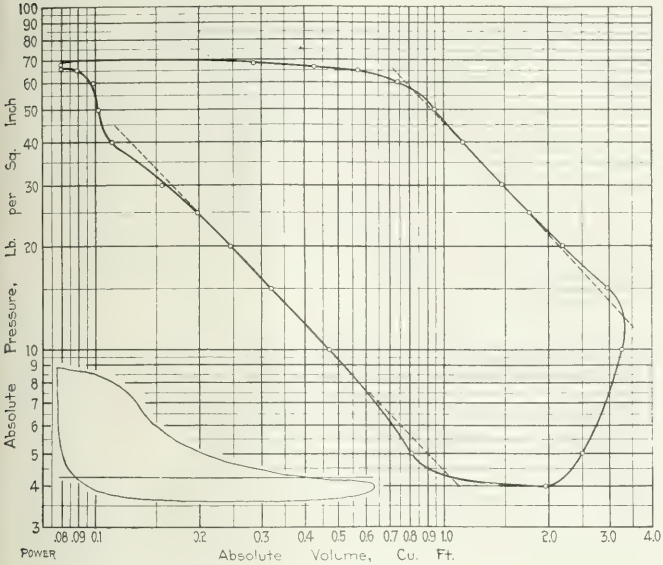


FIG. 6. DIAGRAM FROM LEAKY CORLISS ENGINE

Fig. 6 is from a 14x35-in. Corliss engine. The knowledge of the leaky condition of the piston and valves came from the engineer in charge. The expansion and compression lines indicate by their form at the upper ends a large leak from the cylinder, indicating a leaky piston or exhaust valve or both. The lines also show by the rising of the curves at the lower ends a considerable addition to the steam in the cylinder during expansion and compression. This steam could come only from a leak in the steam valve.

Fig. 7 is from an 11¼x22-in. double-acting ammonia compressor, the cylinder of which was known to be in very bad condition as regards wear and leakage of piston and valves. The reëxpansion curves, by the enormous amount of reëxpansion shown, indicate large leakage into the cylinder during this operation. The lower part of the compression curves, by rising, indicates leakage into the cylinder either past the piston or through the discharge valves. The upper part of these curves indicates leakage from the cylinder either past the piston or through the suction valves.

Very smooth curves may be obtained in the indicator diagram even if there is considerable leakage taking place. The expansion and compression curves of the *pv* diagram, Fig. 6, are fairly regular, but the logarithmic diagram shows plainly that large leakage of two kinds was taking place during expansion and compression. Leakage which takes place during admission or exhaust has no effect upon the lines of the diagram as the weight of the medium is continually changing.

In discussing leakage it must be kept in mind that difference in pressure between two regions is the cause of the phenomenon. In the steam engine there are three pressures which must be considered, that in the steam chest, in the cylinder and in the exhaust passage. Leakage, being due to difference in pressure, becomes material only when this difference becomes considerable. The leakage into or out from a steam cylinder has been found to occur in most cases only when the pressure difference is over about 20 lb.

In Fig. 6 the leakage into the cylinder, shown by the lower parts of the line, begins to occur at about 25 lb. absolute or 35 lb. lower than the pressure at admission. The leakage out from the cylinder, shown by the upper parts of the line, ceases to occur at a pressure of about 40 lb. absolute for the expansion curve and begins to occur at about 25 lb. absolute for the compression curve. The difference of pressure between the steam in the cylinder and that in the exhaust passage is about 35 lb. in the first case, and about 20 lb. in the second case.

This fact, founded upon many diagrams analyzed, permits the division of the expansion and compression lines roughly into three equal parts on the logarithmic diagram (when these lines extend from the initial pressure nearly to the back pressure): (a) the upper third, influenced by leaks *out from* the cylinder; (b) the middle third, practically *uninfluenced* by leakage; (c) the lower third, influenced by leakage *into* the cylinder. Thus fairly reliable values of *n* free from the effects of leakage may be obtained from the middle third of the lines. Ordinarily it is not possible to distinguish between two leaks occurring in the same third of the curves.

When only one kind of leakage exists it is possible to compute with fair accuracy the volume of leakage taking place during expansion or compression. In Fig. 5 the lines are extended (as shown dotted), giving the lines of constant weight of medium. If there had been no leak the volume at 100 lb. pressure would be that indicated by the intersec-

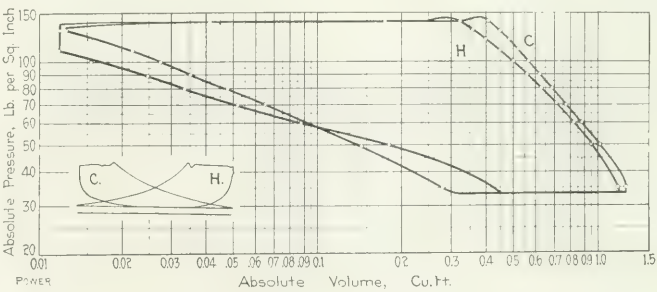


FIG. 7. DIAGRAMS FROM LEAKY AMMONIA COMPRESSOR

tion of the dotted extension of the compression line at *C*. The volume actually present is indicated by the location of the point *A*. The difference between the volume indicated by *A* and *C* is a measure of the leakage. The important thing, however, is the indication that leakage is taking place so that it may be stopped.

Determining the Clearance

The curves of the indicator diagram will become straight lines upon the logarithmic paper only when the pressures and volume are measured from absolute zero. If there is any mistake made in locating the line of zero pressure or the clearance line, the replotted expansion and compression lines will be curved. If the clearance is not known it may be determined by plotting the logarithmic diagram for a number of assumed clearances until the compression line becomes straight. This was done in Fig. 8, which is from a 42x60-in. gas engine using blast-furnace gas. Curves, both expansion and compression, were plotted for 14, 16, 18, 20 and 22 per cent. of clearance. With the true clearance of 18 per cent., the curves become straight lines. With values of the clearance less than 18, the curves become bent to the left; with the value above 18, to the right.

If the clearance is accurately known, the position of the line of absolute zeros of pressure may be located in the same way, thus determining the barometric pressure if the atmospheric pressure and the scale of the spring are given, or the scale of the spring if the atmospheric pressure and reading of the barometer are given. The compression line gives naturally the better indication, as shown by the wider spacing and more decided curvature of the compression curves produced with the erroneously assumed clearances in Fig. 8.

Steam Consumption from the Diagram

The indicator diagram shows the pressure of the steam in the cylinder at the point of cutoff. From the steam tables its weight per cubic foot at this pressure may be determined. Knowing the volume of the cylinder up to cutoff and the number of times it is filled per hour, it would seem that the weight of steam thus metered off could be computed; and it could if the contents of the cylinder at the instant of cutoff were all steam. As a matter of fact, the steam consumption computed from the diagram in this way will be from 15 to 50 per cent. too low because some of the entering steam has condensed upon the surfaces which have just been exposed to the cooler exhaust, and is present as water when cutoff takes place.

As the pressure is lowered by expansion below that corresponding to the temperature of this water, a portion of the steam is reëvaporated, changing the course of the expansion line, and the most significant point brought out by Mr. Clayton's paper is that the line remains a true exponential curve and that the value of *n* bears a definite relation in any given cylinder to the proportion of the total weight of steam mixture which was present as steam at cutoff.

Furthermore, the relation of *n* to this initial quality for the same class of cylinder as regards jacketing has been found to be practically independent of engine speed and of cylinder size. If one can determine then the exponent of the curve of a given diagram, and knows the quality of the mixture at cutoff corresponding to that exponent, he can compute from the diagram the amount of steam actually used by the engine with a degree of accuracy limited only by the accuracy with which these quantities are known.

The method of determining the value of the exponent from the slope of the expansion curve has already been explained.

In Fig. 9 is given a chart from which the quality at cutoff for any value of *n* between 0.85 and 1.25 and for any pressure at cutoff between 40 and 160 lb. absolute may be measured. For $n = 0.95$, for instance, the quality at cutoff is a little less than 0.51; at 60 lb. a little less than half way between the curved lines representing 0.56 and 0.58. At 100 lb. it is nearly 0.62, etc.

This chart is plotted from the results of tests upon a 12x24-in. Corliss engine exhausting into a condenser in order that the condensate might be weighed, but at about atmospheric pressure. The speed had a slight effect upon the quality at cutoff and the chart is plotted for 120 r.p.m.

The effect of a change of pressure on the relations of the quality at cutoff and *n* is not great between the limits of 75 to 150 lb. An approximate equation, correct for the conditions at 129 lb. absolute representing the average of the range mentioned, is

$$X_c = 1.245\, n - 0.576$$

where

X_c = Proportion by weight of the mixture present as steam at cutoff;

and

n = Exponent of v in the equation $pv^n = con.$

This quantity for the ordinary case will be less than unity, and dividing the weight per cubic foot of dry saturated steam at the cutoff pressure, as given by the steam table, by it will give the weight per cubic foot of the mixture. Multiplying the volume of the cylinder up

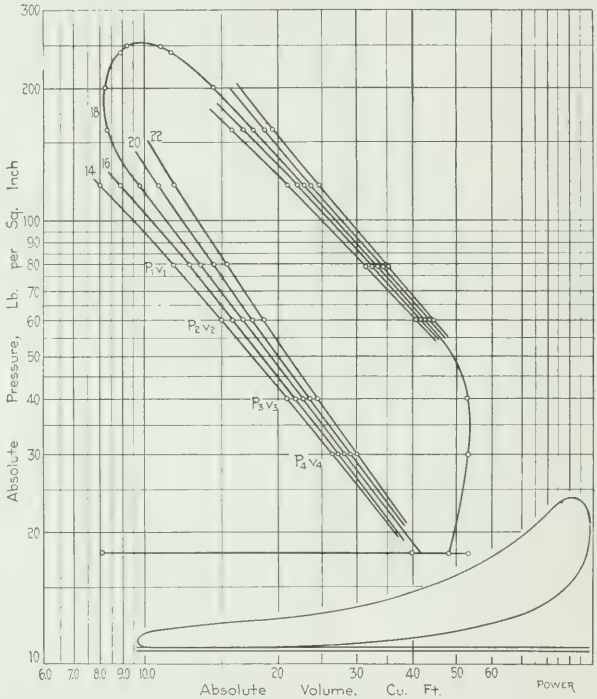


Fig. 8. Diagram from Gas Engine with Blast Furnace Gas

to the point of cutoff in cubic feet by the weight per cubic foot will give the weight of steam and water present in the cylinder at the point of cutoff.

But not all of this came in when the valve was opened for admission. There was some saved from the previous stroke by closing the exhaust valve before the stroke was finished. It has been demonstrated by George Duchesne* that this steam at the commencement of compression is dry saturated. After the exhaust valve has become fully seated and the weight of steam being compressed has become constant, the compression line will be straight upon the logarithmic diagram as between *A* and *B*, Fig. 3. If this line is projected downward as by the dotted line *BC*, the intersection with the back-pressure line of the diagram will indicate the volume of dry saturated steam of that pressure present. The weight of the volume at that pressure can then be taken from that present at cutoff and the difference will be the weight supplied per stroke, which multiplied by the number of strokes per hour will give the weight supplied from the boiler for that end of the cylinder.

The results of the applications made up to the present tend to show that the steam consumption of engines may be approximated from the indicator diagram to within an average difference of less than 4 per cent. from the test results. Individual examples, however, may show as much as 8 per cent. in rare cases.

*Power, Jan. 10, 1911, page 71.

Further investigations of the relations of X_c and n with all types of engines running under all sorts of conditions may lead to the evolution of a set of tables or charts of these relations which can be used with confidence that they will give a sufficiently close approximation to the actual consumption of the engine to allow that consumption to be computed from the indicator diagram instead of laboriously being measured in an expensive test. An engine which would otherwise be tested perhaps once in its lifetime may have its water rate determined frequently with little more labor than is now spent upon the worthless uncorrected consumption from the diagram, and such easily made determinations may serve all the purpose of expensive tests except where large bonuses or forfeits are involved, and even in these cases would serve as a check upon the test figures.

The paper contains tables of results from tests of numerous engines, an explanation of the development of the chart shown in Fig. 6, diagrams from various engines, including the Diesel, the Stumpf unidirectional flow, combined diagrams from compound- and triple-expansion engines, and much material of value to the student of indicator diagrams.

For the year 1910, reports the Department of Mines of Western Australia, there were 58 gas engines in use in mines developing 607 hp., while 2933 hp. was developed by 420 oil engines.

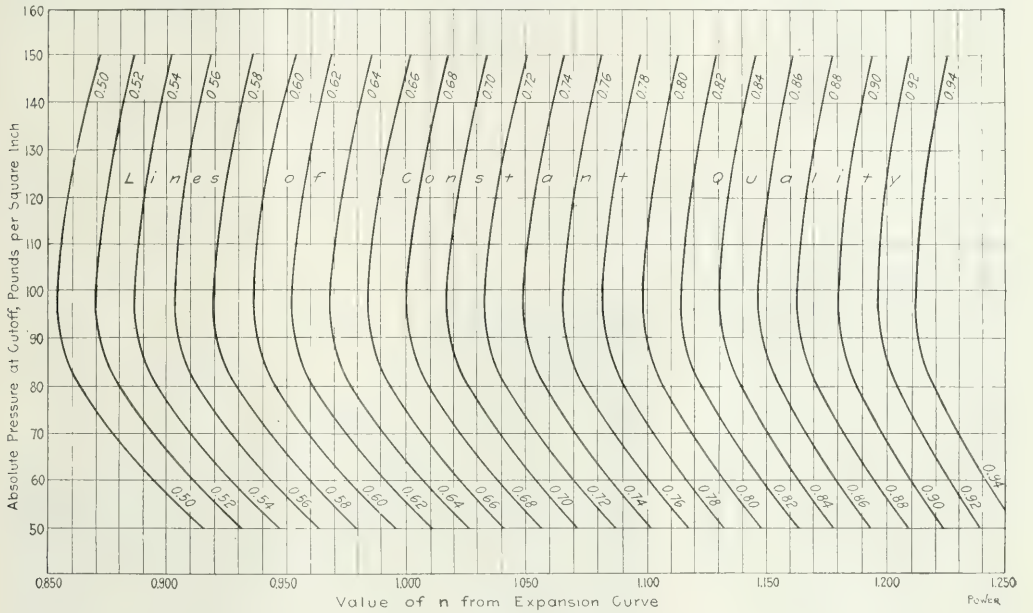


FIG. 9. THE RELATION BETWEEN PRESSURE AT CUTOFF AND VALUES *n* FOR CONSTANT QUALITY AT CUTOFF

Furnace Arches

BY W. H. BOOTH

Under the severe conditions to which brick furnace arches are subjected, it is a wonder that they last as long as they do. Many who have to deal with firebricks are content to purchase them from some convenient supply house and they may have been exposed to the weather and be saturated with moisture.

Damp bricks should never be put into a furnace arch, but should be stored in a place where they will be thoroughly dried out before using. If it is not possible to so store them, they should be kept as dry as conditions will permit and brought into a dry, warm place two or three weeks before being used. It is then possible to build an arch, using a little fireclay as a jointing material.

An arch should be given time to dry out slowly, first letting a gentle draft pass through the cold furnace and then maintaining a slow fire for several days.

Thin joints are essential to longevity, and this should rule out all bricks not properly tapered to fit the radius of the arch in order that the joints may be even throughout. The best fire arch bricks are those which taper lengthwise. Some are made with a horizontal projection on one side to fit as a key into an inverted hollow on the other side of the next brick. Any attempt to use rectangular bricks is fatal to rigidity as the bricks will ride together on the inner curve of the arch and will soon work loose and

collapse. If the jointing material is made into a grout into which the bricks are dipped, they may be rubbed together to exclude any surplus clay and a solid arch will result, if dried out slowly.

The side walls of a boiler setting must be capable of withstanding the lateral thrust of a flat arch. This stability can always be insured by stout supports of girder iron sunk below the ground and held together above the boiler by cross tie rods.

When carefully treated the furnace arch becomes cemented into a uniform mass by the fusion of the bricks, but this will occur only in a well built arch. When it does occur, it prolongs the life of the arch.

Safeguards for Power Plant Equipment

By Edward K. Hammond

A description of several devices for preventing accidents.

They are practical, and so simple that the ordinary engineer can make and install them at small expense.

Statisticians have estimated that, each year, from 30,000 to 35,000 wage earners in the United States lose their lives as the result of industrial accidents and that about 2,000,000 nonfatal accidents occur. Probably 60 per cent. of these accidents are either the result of the injured person's carelessness or are due to the absence of proper safeguards.

It is particularly true that the carelessness of any power-plant operator not only endangers his own safety but that of others; consequently new men should be instructed about the dangers incident to their work and the most rigid discipline maintained to enforce all precautionary measures. The importance of this careful attention can best be kept before the operator by hanging framed safety rules in conspicuous places in the plant.

Railed Walks

Where coal cars are switched to a trestle to deliver fuel to the bunkers, there are two possibilities for accidents; a man may be caught where there is no room for him to avoid the moving cars; or persons passing under the trestle may be injured by falling material. Fig. 1 illustrates a trestle where these dangers have been safeguarded. Railed walks have been provided along either side of the trestle with a platform between the tracks, the walks having base boards which prevent loose material from being kicked off the trestle, or a man slipping on the walk and falling under the hand rail. The standard calls for a walk 4 ft. 3 in. wide with a metal hand railing 3 ft. 6 in. above the walk and a toe board 6 in. high. If a driveway or walk passes under the trestle, the structure is completely planked over at this point.

Railed walks and permanent ladders leading to platforms which carry the operators within reach of all valves in the plant are good. Fig. 2 illustrates the interior of a plant so equipped. These walks not only save loss of time in shutting off the steam in case of an emergency, but also do away with the probability of serious falls. Railed walks are also used on each boiler in the plant and lead from boiler to boiler.

It is important to have two valves between the boiler and its header when two or more boilers are connected to it. A man cannot do good work in a boiler if he feels insecure, and no man should be exposed to danger for the sake of saving the extra expense of a second valve. A locking lever for preventing the accidental opening of valves on the boiler steam, feed and blowoff pipes while men are in the boilers making repairs or inspections is shown in Fig. 3.

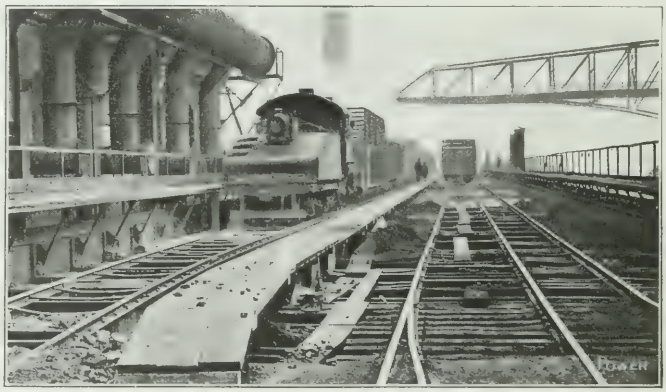


Fig. 1. Trestle with Railed Walks

To release this lever a man must use one hand to depress the spring and the other to throw over the catch *A*; this makes it impossible for a valve thus secured to be accidentally opened. A warning notice stating that the boiler is down is used in connection with this locking lever, the notice being hung on the closed valve. There is, therefore, no excuse for injury through the accidental opening of a valve. As a further precaution, however, it is advisable for a man about to enter a boiler to notify all of the workmen in that section of the plant.

Care of Boilers

After opening the manholes the damper should be opened to produce a current of air through the boiler and carry off any inflammable vapor. Accidents from explosions in boilers where kerosene has been used or where sewer gas may have entered will be avoided by observing this precaution.

Pipes discharging at points where passersby are likely to be scalded should discharge into exhaust pits and these pits should be covered with something suitable for the use over hot-water sewers.

It is of utmost importance that each boiler have a steam gage, so mounted as to make it possible for it to give accurate indications. In connecting a gage the piping should be as short as possible with nothing in the piping between the boiler and its gage except the gage-cock. In the piping should be a water-pocket that high-temperature steam may not come into direct contact with the bent gage tube and draw its temper, thus causing the gage to give incorrect readings. All of the gages in the plant should be calibrated at regular intervals to insure their accuracy.

Gage-glass Guard

Fig. 4 illustrates a guard to prevent injury to the man putting in a new gage-glass. This guard consists of a semi-cylindrical piece of sheet metal mounted on a pivot at either end so that it can swing around the glass. When a new glass is being warmed up, the guard is placed between it and the operator where it will protect him from flying pieces of glass and, to some extent, from the

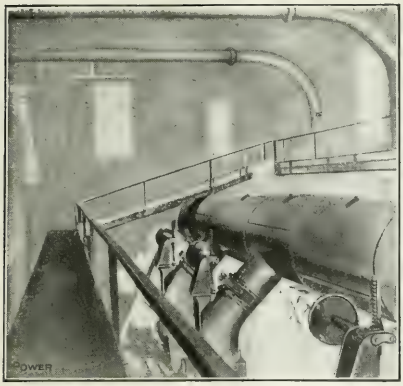


FIG. 2. RAILED WALK ABOVE BOILERS

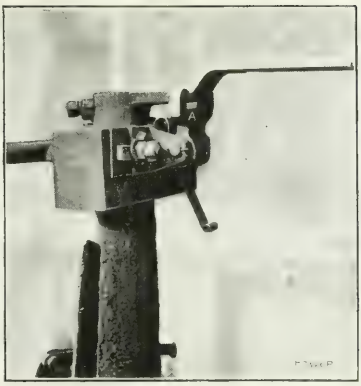


FIG. 3. LOCKING LEVER

FIG. 4. GAGE-GLASS GUARD

steam and hot water if the tube bursts. After the new glass has been subjected to a fair test in this way, the guard is swung around to the back of the glass, where it does not obstruct the view. The guard is shown in this position. A lamp close to the gage illuminates it.

SCALE

Although scale frequently causes boiler accidents, some power-plant operators regard its formation as of little importance, but such an accumulation causes overheating of the plates, which reduces their strength. When heavy scale forms on the tubes and tube sheets the tube ends are burned and soon leak at their connection in the tube heads. Other dangers from scale in a boiler are incorrect water levels and pressure readings due to clogging of the pipes leading to the gages and of the feed pipes.

FLYWHEEL EXPLOSION

The most serious hazard connected with the operation of engines is that of the flywheel bursting, usually caused by centrifugal force. To minimize flywheel accidents correct design is the first essential, but even properly designed wheels may burst if run above their safe speed. Overloading causes a flywheel to fail because of the bending stresses in the spokes.

In addition to the danger from bursting, flywheels are a menace from the chance of accidental contact with them; therefore it is well to surround them with railings. Fig. 5 is a view in a power plant where the flywheel is thus railed off, a substantial metal guard being provided at the base to prevent a man slipping under the rail and into the flywheel pit. Railed stairs and walks are provided wherever it is necessary for an oiler to go on the engine.

Fig. 6 shows a turbine-generating set in which the flexible shaft coupling is completely inclosed; this keeps dirt away from the bearings and eliminates danger of a man being caught by the coupling.

ELECTRICAL SAFEGUARDS

While the precautions to be observed in the design and operation of electrical switchboards and equipment are too numerous to receive detailed treatment, certain rules are fundamental. All switchboards, dynamos and motors of over 250 volts should be thoroughly grounded, and surrounded by railings of a nonconducting material. The terminals and other parts of high-voltage dynamos and motors should be inclosed, or so arranged as to preclude possibility of an operator touching them directly or with a conducting tool.

Several good features may be seen on the electrical equipment in Fig. 7. The switchboard operator stands on a rubber mat placed on a wooden platform. Use of rubber mats around all machines is strongly advised, thus reducing the

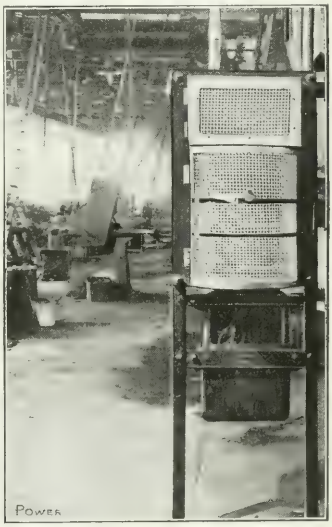


FIG. 8. SWITCH GUARD

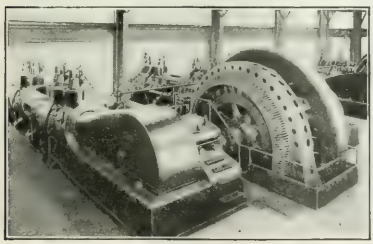


FIG. 5. GUARDED GENERATOR SET

FIG. 6. HOUSED TURBINE COUPLING

FIG. 7. BELT GUARD

chance of an operator slipping and being injured by moving parts. At the back of the switchboard ample working space has been left, and this is always kept unobstructed. When working on the board the operator should use rubber gloves, and switches should be provided to make the board "dead" when such work has to be done. Many plants provide for shutting off the space at the back of the switchboards whenever men are not engaged in making repairs and adjustments. Guard rails are shown at each belt driving the generators.

Fig. 8 illustrates another safety device which incloses the electrical switches in the factory so that men ignorant of their danger cannot be injured.

Inspection

All of the equipment in the power plant should be inspected at regular intervals. Whenever a boiler is put out of commission, a complete inspection should be made, the plates examined for cracks, the stays tested for tightness and the drum connections examined for pitting. Flywheels should also be carefully examined for cracks which usually develo in the under side of the rim near th spokes and if not detected will graduall increase in size and cause the wheel t fail.

Signed inspectors' forms on whic is reported the result of all inspection are valuable as they can be filed fo reference and in case of acciden make possible placing responsibility fo any negligence where it belongs. Th normal influence of such a system tend to keep the inspecting from bein slighted.

The Bloomington Boiler Explosion

A locomotive boiler explodes in Bloomington, Ind., killing the engineer and seriously injuring the fireman.

The shell is stripped of all piping and attachments, the crown sheet torn away and the shell hurled 240 ft. The tubes were but slightly distorted.

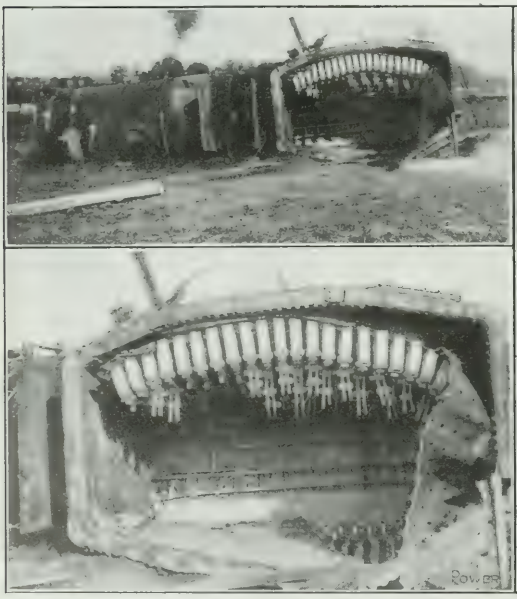
A press report of this locomotive-boiler explosion was published in the May 7 issue, but the following details were then unavailable:

At about noon of Sunday, Apr. 21, engine No. 127 was drilling in the Monon yards at Bloomington, Ind., when the boiler exploded, hurling the engineer through the box car, shown in Fig. 1, and killing him instantly. The fireman was standing on the tender at the time and was thrown over a caboose, landing about 75 ft. away; though seriously injured, he is said to be recovering. It was a Baldwin locomotive, dated April, 1892, and numbered 12,617, and was rebuilt and used for drilling purposes only up to the time it exploded. It is said that the engine was condemned a short time prior to the explosion.

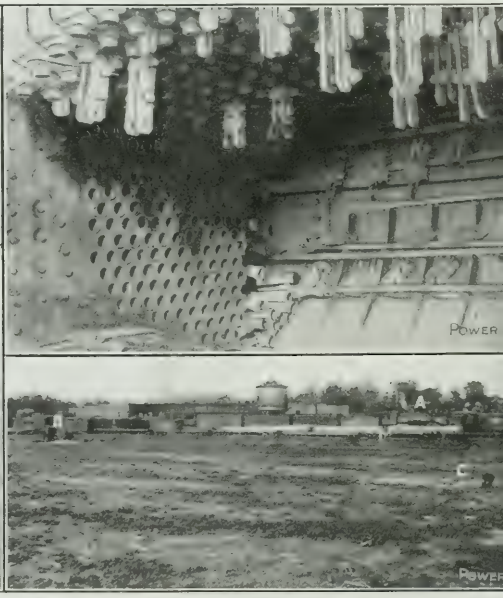
The cause of the explosion is as yet unknown, but much lime deposit in the form of scale was found about the boiler near the spot at which the explosion occurred, showing that it was heavily scaled.

All the piping and attachments (Figs. 1 and 6) were stripped from the boiler, leaving only the shell and firebox intact. The air pump, however, was ca ried with the boiler for a considerabl distance before it was torn from th shell and imbedded itself in the eart 350 ft. away. It appears that the pum was partially torn from the boiler at th moment of the explosion and when th latter turned over in the air the pum was then severed.

As the explosion was downwar through the firebox, the trucks, engin cylinders, etc., remained on the trac and were but slightly damaged. It peculiar that the tubes were so slightl distorted (see Figs. 3 and 6). Despi the fact that the piping and attachment were cleanly cut from the shell, its onl appreciable damage was to the crow sheet, which was torn away and lodge in front of the firebox (Fig. 2).



Figs. 1 and 2. Showing Firebox



Figs. 3 and 4. Interior of Firebox and Location of Parts After Explosion

FIG. 5. WRECKED FREIGHT CAR

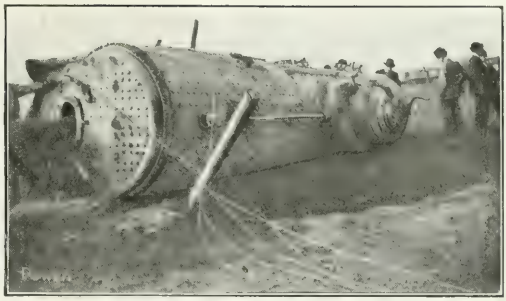


FIG. 6. SHOWING SHELL INTACT

Fig. 4 shows a general view of the yards. The arrow *A* indicates the location of the locomotive at the time of the explosion; the locomotive shown at this point is of the same type as the one wrecked. Arrow *B* shows the boiler resting against a fence about 240 ft. distant, and arrow *C* gives the position of the air pump which is so deeply imbedded in the earth as to be almost indistinguishable in the photograph.

The Solignac-Grille Boiler

Among boilers employing small-diameter water tubes for rapid steaming, the new Solignac-Grille boiler, made by Grille & Co., Paris, France, presents some original features in its circulating and superheating systems, and the means employed for cleaning the tubes. The manner of circulating the water and passing the steam through the tubes is quite different from that employed by other boilers. One novelty is the introduction at the feed-water end of the tube of a supplementary resistance, preventing escape of steam in a direction to interrupt the inflow of water and admitting water only as fast as it can be vaporized in the tube.

Before describing the boiler, it might be well to briefly outline the experimental demonstration of the reasons for adopting a device to insure regular circulation, which were given at some length by *Engineering* in an abstract of a paper read by G. Hart before the Institution of Naval Architects.

Investigations on water circulation in boilers by Mr. Bellens have shown that the evolution of steam is not continuous, but intermittent and in the form of very large steam bubbles. By means of a sighting hole fitted with a glass cover it was also shown that the water descends between two escapes of steam by the path of this escape. It was to do away with such spasmodic emissions of steam and reverses of direction that Mr. Solignac conceived the idea of fitting at the lower end of the tube a diaphragm creating a supplementary resistance which should prevent any escape of steam at the lower end.

As a basis for this design he took the result of the following experiments: Two similar vessels, such as are shown in Fig. 1, were placed in the same horizontal plane and connected by a horizontal metallic tube. The tube was heated and

A water-tube boiler in which the steam in formation does not pass through the water.

The entire boiler may be turned on a pivot out of the setting.

the steam escaped intermittently from the two ends. The heated portion became red hot and the water which the tube contained was converted into steam. This steam escaped as often as its pressure exceeded the resistance caused by the head of water above the tube; then it escaped with a sudden rush and each time water again filled the entire tube. When the water rushed into the tube, a rapid hammering could be heard, which decreased as the temperature of the feed water rose.

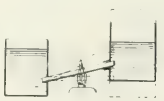


FIG. 1

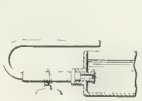


FIG. 2

By carefully raising one of the vessels so as to give more inclination to the tube, the phenomena were modified according to the inclination. As long as it was slight and did not exceed the diameter of the tube the effects observed were nearly the same as when the tube was horizontal, but as the inclination of the tube increased a larger quantity of steam escaped at the side next to the upper end, while the water in the vessel on this side was also heated to a higher temperature.

That the escape of steam was never regular, and had periods of variable intensity, was shown by hanging on the upper end of the tube a small thin shutter, which lifted with each discharge of steam. While there was only an occasional escape of steam from the lower end of the tube, a liquid film of viscous appearance could be seen descending in it just prior to each discharge of steam at the upper end. With the same apparatus a reducing diaphragm was fitted at the lower end of the tube and the phenomena of circulation became quite different. Steam then escaped continuously from the free end. The tube no longer became red hot, the water in the vessel on the diaphragm side remained cold and the water in the other vessel was heated rapidly. Finally, the level of the water became lower in the vessel on the diaphragm side and rose in the other an amount varying with the inclination of the tube. This experiment was supplemented by another with the bent tube shown in Fig. 2. The same phenomena were observed and the same results obtained, indicating that the diaphragm is the proper regulating device to afford a continuous flow of steam.

The sectional view, Fig. 3, reveals the general design and arrangement of the boiler, consisting of a horizontal drum with two attached compartments into which the tubes are expanded. Water is admitted into the lower compartment *A* through a valve *B* and its flow into the tubes is restricted by the diaphragm previously mentioned. Steam escapes from the tubes into the upper compartment or steam chest *C* and passes into the main drum from which the supply of water is drawn. The steam, not being compelled to cross the water surface but escaping above it, is much drier than in boilers where it has to pass through the water. The proportion of moisture is very small,

not exceeding a few thousandths. The arrangement does away with tumultuous ebullition and consequent rushes of water, particularly as the main drum and steam chest are not exposed to intense heat, and repairing the brickwork surrounding the boiler.

For marine service preheating of the air supply is possible by using double walls. The external facing plates of the boiler opposite to the furnace are composed of riveted sectional cells inside of which refractory brickwork is built up. Through these sections air is passed before entering under the grate so that the ashpit doors, having but little air to supply, are very seldom used in ordinary service. This arrangement has the advantage of cooling the external facing plates while preheating the air, and this constitutes a means of recovering part of the heat wasted by radiation. The air entering the cells can be controlled by movable shutters according to the intended rate of combustion.

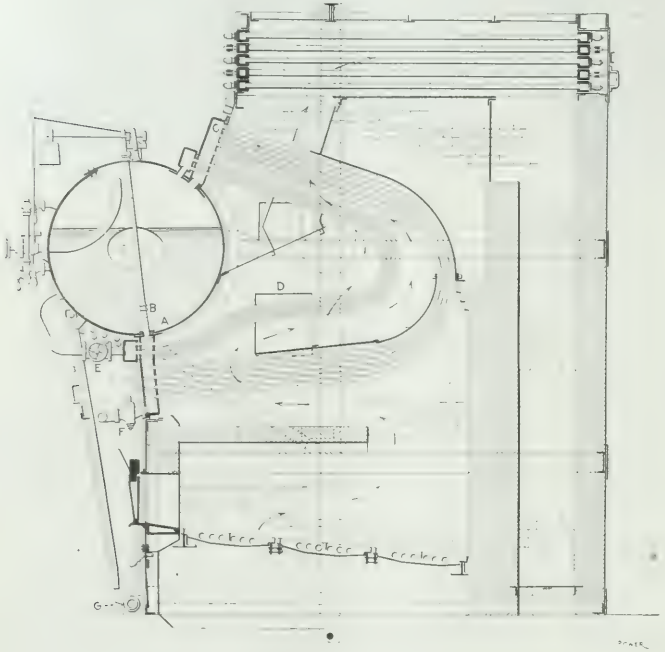


FIG. 3. SECTIONAL VIEW THROUGH GRILLE BOILER, EQUIPPED WITH SUPERHEATER AND ECONOMIZER.

as may be seen from the path of the gases of combustion, indicated by the arrows in the illustration. The superheating tubes are shown at *D* and may be made auxiliary to the regular heating surface by flooding them through the valve *E*.

Next to the diaphragms the manner of cleaning is most interesting. The valve *B* is closed, shutting off the main drum from the lower compartment. Then by opening valve *F* steam under boiler pressure from the upper compartment flows in a reverse direction through the tubes and blows out the scale. The tubes, now containing no water, become hotter than normally and expanding loosen the scale which is readily carried away through the blowoff valve. The tubes are only left 30 sec. without water, which is long enough to detach the scale without injuring the tubes. The cleaning is made still easier by the division of the tubes into several groups, each corresponding to an element of the boiler shell, the various elements having nothing in common but the steam and water chests.

A third feature, which is altogether unusual, is a device which allows the whole boiler and the group of tubes to be swung around a pivot *G* for inspecting

Numerous tests on this boiler have shown the rate of combustion with a maximum output to average about 30 lb. of coal per square foot of grate, which would give an evaporation from feed water at 55 deg. of approximately 9 lb. of water. With a very slight reduction of efficiency, the rate of combustion may be increased to 40 lb. per square foot of grate. The boiler is a quick steamer, occupies comparatively small floor space, has the advantage of easy internal cleaning and, above all, produces dry steam, which becomes especially valuable where steam turbines are used aboardship.

Improved Pratt Trap

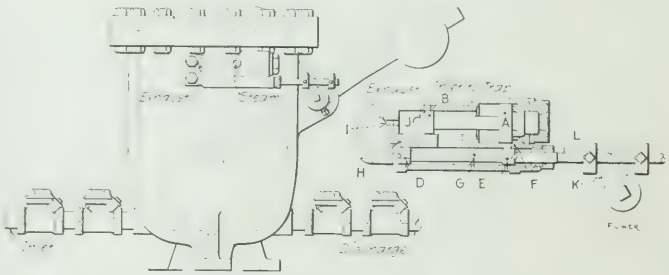
This trap consists of a cast-iron body containing a cast-iron float which works on a trunnion arm. The float is balanced on the outside by a weight and lever, the lever operating the valve mechanism, which is bolted to the side of the trap; its function is to alternately admit steam to the trap or exhaust it to the atmosphere.

Steam enters the side of the valve casting between the pistons *A*, *B*, *D* and *E*, and the piston *A*, being of larger area than the piston *B*, is forced to the right. The right side of the piston *A* is connected to the exhaust through the ports *F*, *G*, *H* and *I*. The small piston *B* is exposed to the exhaust on the left side. In this position the interior of the trap is connected to the atmosphere through the ports *J* and *I*.

Condensation enters the trap through the left check valves and in filling it the float gradually rises and the lever *K* moves the valve rod *L* toward the right until the position of the valve is such that the steam will enter the port *F* to the right side of the piston *A* and force it to the left, thus connecting the port *J* with the steam chamber.

Steam then enters the trap above the water and balances the boiler pressure on the discharge side, with the pressure in the trap, which then discharges to the boiler by gravity.

This trap is manufactured by the Pratt & Cady Co., Hartford, Conn.



IMPROVED PRATT TRAP

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Transformer Connections

By Cecil P. Poole

Testing for Three-phase Connections

In connecting transformers either delta- or star-fashion, care must be taken to make the secondary connections correspond exactly with the primary connections as regards relative polarities and phase "rotation." If this is not done, a short-circuit may be caused with delta-connected secondary windings and incorrect voltages will be obtained with star-connected secondary windings.

When the primary and secondary leads are both connected in delta or both star-connected, it is an easy matter to get the connections right. It is only necessary to get the primary terminals connected up properly, as described in the

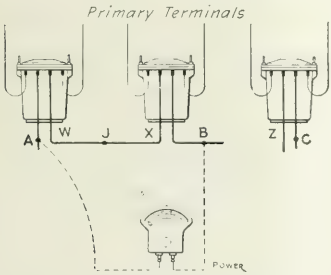


Fig. Testing First Transformer for Three-phase Connection

preceding article (May 14 issue), test the secondary winding of each transformer to ascertain the instantaneous polarity with respect to its primary terminals, as described in the first article, on single-phase connections (May 7 issue), and then connect the secondary leads from the three transformers exactly as the primary leads have been connected.

If the primary terminals of the transformers are delta-connected and it is desired to connect the secondary terminals star-fashion, or when the primaries are star-connected and it is desired to connect the secondary windings in delta, the method just outlined cannot be applied, because of the difference between star and delta connections. In such cases, the primary windings should be connected up permanently, just as they are expected to be operated, and the secondary connections tested out as follows:

For delta-connected secondary windings, twist one secondary lead from one transformer to one of the leads from the next transformer, temporarily, as indicated in Fig. 1, and measure the voltage between the two free secondary leads, *A* and *B*. If it is the same as the voltage between the twisted joint *J* and either of the terminals *A* or *B*, of the transformers temporarily connected, this connection is correct and the joint *J* should be made permanent. If, however, the voltage between the two free terminals *A* and *B* is about 1¾ times the voltage between the joint *J* and either one of the terminals, then the connection is wrong and the free terminal *B* of the second transformer should be connected to the joint lead *W* of the first one instead of the lead *X*.

Having connected the first two transformers properly, attach one of the leads of the third transformer to the free terminal of the second one and measure the voltage between the free leads of the first and third transformers, as represented in Fig. 2, where these free leads are marked *A* and *C*. If the connection between the second and third transformers is right, the voltage between the free leads *A* and *C* will be the same as the voltage between the two leads of any one transformer, as *A* and *W*, or *B* and *X*, or *C* and *Z*. If it is wrong, the voltage between *A* and *C* will be about twice as great as the voltage between the two

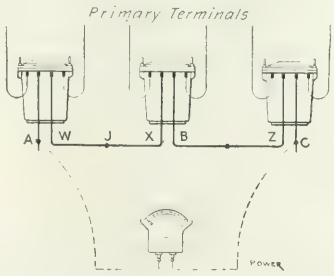


Fig. 2. Testing Third Transformer for Delta Connection

leads of any one transformer; in that case, the leads from the third transformer must be reversed, the lead *C* being connected to the lead *B* and the lead *Z* to the lead *A*.

For star-connected secondary windings, twist one lead of the first transformer to one lead of the second transformer as before and measure the voltage between the two free leads of those two transformers. In this case, that voltage should be about 1¾ times the voltage of any one transformer (theoretically, 1.732 times the transformer voltage). If it measures the same as the voltage of one transformer, the connection is wrong and the leads from the second transformer must be reversed, connecting the lead *B* to the lead *W* and leaving the lead *X* to be connected to the third transformer.

The next step is different from that of the test for delta connections. After the

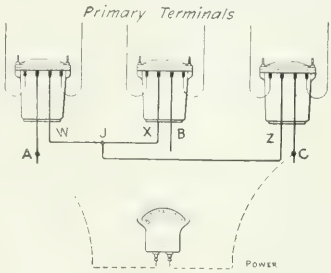


Fig. 3. Testing Third Transformer for Star Connection

first two transformers have been connected properly, one lead of the third transformer must be connected to the joint *J*, as shown in Fig. 3, and the voltage measured between the free leads *B* and *C*, or between the leads *A* and *C*, it matters not which. If this voltage is about 1.7 times the voltage between the joint *J* and any one of the free leads, then the connection is right and should be made permanent. If the voltage between two of the free leads is equal to that between the joint and one of the free leads, the connection is wrong and the leads from the third transformer must be reversed, the lead *C* being connected to the joint *J* and the lead *Z* left free.

Changing the Number of Phases

It is sometimes desirable to change three-phase currents to two-phase currents, or *vice versa,* and this is usually done by the use of the system of connections shown in Fig. 4, which is commonly known as the "Scott connection" because it was originated by Charles F. Scott, at that time chief electrical engineer of the Westinghouse Co. Two transformers are used and they are interconnected as indicated in the diagram, one primary terminal of one being connected to a tap leading out from the middle

of the primary winding of the other, and about 13 per cent. of the primary winding of the first one being omitted from the primary circuit. As this diagram is drawn, the transformers receive their primary currents from a three-phase circuit and deliver two-phase secondary currents. The arrangement works just as well in the reverse direction, however; if two-phase currents are delivered to the two-phase terminals of the transformers, three-phase currents will be delivered from the three-phase terminals. Moreover, the transformers can be so connected as to receive high-tension two-phase currents and deliver low-tension three-phase currents. For this purpose, the primary leads are connected up exactly as the secondary leads are shown in Fig. 4 and the secondary leads and windings are connected up in the way which this diagram shows for the primary windings and leads.

There are other methods of changing three phases to two, or *vice versa,* but none of them is as simple or as advantageous as the Scott method, and they are seldom used.

Six-phase Connections

For supplying current to rotary converters, transformers taking current from

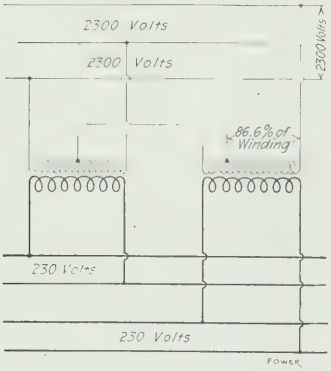


Fig. 4. Scott Connection for Changing Three-phase to Two-phase, or the Reverse

three-phase primary circuits are sometimes connected so as to deliver six-phase currents to the converter. Two methods of doing this are in general use. The simplest method is to carry the six secondary leads from the transformers to the converter without interconnecting them at all, as represented in Fig. 5. Tracing the connections will show that each pair of secondary leads is connected to points in the armature winding of the converter which are at opposite ends of a line drawn straight across from side to side of the armature, through its center; the secondary leads from the *A* transformer, for example, are connected (through brushes and slip rings) to the points *a* and *a'* of the armature winding, and these are at opposite ends of an imaginary horizontal line from one side through the center to the other side of the armature, at the instant represented by the diagram.

The armature shown is that of a bipolar machine, for simplicity. In a multipolar machine there would be three times as many armature taps as there were field magnet poles, but as these do not go beyond the slip rings they do not affect the transformer connections, and it is these with which this article has to do. There are only six slip rings and brush leads on a six-phase converter, no matter how many field magnet poles it may have.

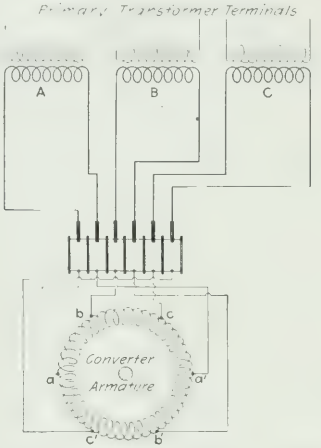


Fig. 5. Connections for Delivering Currents with Standard Transformers

Fig. 6 shows the other method of connecting three transformers for delivering six-phase currents to a rotary converter, which is commonly used. It requires two secondary windings on each transformer and is more complicated so far as making the connections is concerned. Each set of secondary transformer windings is delta-connected and the three leads from each set are connected to three points in the armature which are at equal distances from each other; the three leads from one set of secondary windings alternate with those from the other set.

The two sets of transformer secondary windings are connected oppositely with respect to each other. This is necessary on account of the interspacing of the two sets of leads at the armature winding of the converter. The same result could be obtained by changing the order in which the second set of secondaries is connected and not reversing the terminals of each half secondary, but that would be more complicated than the connections shown in Fig. 6.

The connections in Fig. 5 are nothing more or less than three single-phase connections displaced 120 electrical degrees from each other. There are not six phases until the armature winding is reached, where the intermingling of the three currents produces six phases within the winding.

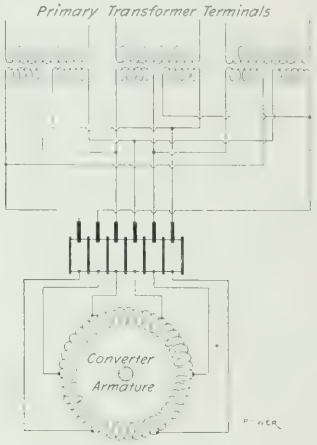


Fig. 6. Six-phase Connections for Double Transformer Secondaries

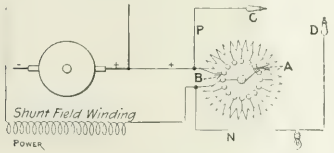
The connections shown in Fig. 6, however, produce six phases right at the transformer terminals, each displaced 60 electrical degrees from the nearest other one. Testing out the connections from transformer to transformer with this arrangement is rather tedious, but not as difficult as the complicated appearance of the diagram would cause one to expect. One set of secondaries is tested out and connected up exactly as explained for the simple three-phase delta connection; then the other set is connected up in exactly the same order but with each pair of secondary leads "crossed" or transposed. This is illustrated by Fig. 7.

Fig. 7. Illustrating the Principle of Six-phase Connections of Double Secondaries

LETTERS

A Convenient Source of Test Voltage

In making repairs to armatures, commutators, etc., it is very convenient to have a source of low-voltage current for testing purposes. The accompanying diagram indicates a method of obtaining a suitable voltage in plants not having batteries or generators especially designed for this purpose. The method consists simply in connecting the test leads, which include an incandescent lamp, in parallel with the generator field rheostat, as shown. The test voltage is determined, of course, by the drop across the resistance of the field rheostat and this can be varied slightly, if necessary, while the test is being made.



CONNECTIONS FOR TEST VOLTAGE

If it should happen that the normal voltage drop across the rheostat terminals is so much too high that a suitable voltage cannot be obtained by adjusting the rheostat arm slightly, it can be got by shifting one of the test leads from the terminal post to one of the contact buttons between the arm and the last "live" contact button. For example, the lead *P* could be attached to one of the buttons between the arm *A* and the end button *B*. The voltage should be high enough to light the test lamp when the testing points *C* and *D* are touched together, and not high enough to strain or break the filament. By using this method no other resistance than the lamp is required, and the leads can be quickly connected.

P. L. WERNER.

McKeesport, Penn.

Commutator Lubrication

Mr. Barrick's letter has us all guessing. I think there is a great difference in dynamos in this respect, and one will work under certain conditions where perhaps another of the same make will fail. I have a compound-wound exciter with which I have to use brushes having a large percentage of graphite in order to make it run at all. On the other hand, in another plant a dynamo working under the same conditions gives no trouble with carbon brushes and a few drops of cylinder oil once a week is all that is required.

One good way to make a carbon brush run smoothly that has been run for some time and hardened is to wash it in gasoline, then soak it in olive oil for 24 hours, after which hang it in a warm place until dry. To clean a commutator that is not scored, moisten a cloth with a little kerosene and wipe lightly when running.

V. C. WOOD.

Copenhagen, N. Y.

In answer to Mr. Barrick's letter in the Apr. 30 issue, I have found that vaseline applied to the commutator with a nonlinting cloth is very satisfactory. There is also a good compound on the market which, as far as I know, is composed of graphite and paraffine. It is in stick form and is applied after the commutator has been wiped clean with a dry rag. After applying it the commutator should be wiped clean again after a short interval.

EUGENE M. HILBERT.

East Rutherford, N. J.

Careless Switchboard Connections

Some time ago I visited a small plant just in time to get a little experience that does not happen every day. This plant contained a 20-kw. direct-current generator used for lighting only and such appliances as are necessary for a machine of this size. Suddenly the lights began to get dim, the engine began to show distress, with plenty of steam registering on the gage, and the engineer tried in every way he knew to raise the voltage, but without success.

I suggested that a cross or short-circuit had occurred somewhere, but at that instant the proprietor came rushing in and he assured us that it could not be a line trouble because he had done all the wiring himself.

I looked around behind the switchboard and the accompanying drawing shows what I found. A new circuit had been put in the day before, but had not been used during the previous night. This circuit was connected to the terminal screws holding the leads coming from the generator to the switchboard so that only a part of the real load was showing on the ammeter. Temporary connections were made by the engineer, as shown by the dotted line, and the switch *B* was opened; 45 amperes more were indicated by the ammeter than had been shown before.

HUGH L. RUSSELL.

Keams Cañon, Ariz.

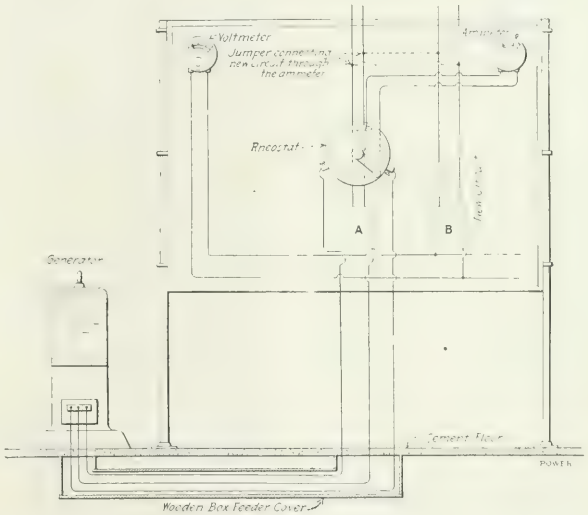
Motors Will Not Carry the Load

I have a 7½ two-phase induction motor operating an elevator. The bearing next to the pulley became so worn that the rotor came in contact with the stator, causing the insulation to break down. The bars of the rotor are fastened to the short-circuiting rings by screws. After removing each bar and insulating thoroughly I replaced them and put the motor in operation. The motor runs all right until there is a load applied and then it drops much below normal speed and will hardly pull the load. I have failed to find any loose connections and the motor does not heat when in operation.

I had another motor of the same type except that the bars were held in brass disks at each end and were soldered. This motor persistently threw its solder on one end and caused a bad connection between the bars and the disks. The other end runs without heating. This motor also refuses to pull a full load.

Will some reader enlighten me regard ing the trouble?

Hopkinsville, Ky. J. L. SHRODE



WIRING CONNECTIONS ON SWITCHBOARD

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Properties of Natural Gas

Thomas R. Weymouth, in a paper read at the recent meeting of the American Society of Mechanical Engineers in Cleveland discussed to some length the properties of natural gas and submitted a table showing the analyses of gases from the principal gas fields of the United States.

A striking feature of the table was the apparent lack of uniformity in the composition of the gases from different fields, and the great preponderance of hydrocarbons, especially of the methane or paraffin group. This has the general chemical formula $C_nH_{2n}+2$, its chief member being methane or marsh gas (CH_4). The percentage of methane was shown to vary from 14 to 97, although the lower figures applied to only a few special cases. It possesses a high heat value, but has practically no illuminating properties.

Without attempting to print the table in full and excluding those samples that came from shallow wells and were otherwise abnormal, the following is an average of the samples tabulated:

TABLE 1 COMPOSITION OF AVERAGE NATURAL GAS

Methane (CH_4)	87 per cent.
Ethane (C_2H_6)	6.5 per cent.
Ethylene (C_2H_4)	0.2 per cent.
Carbon monoxide (CO)	0.2 per cent.
Hydrogen (H_2)	trace
Nitrogen (N_2)	5.5 per cent.
Carbon dioxide (CO_2)	0.5 per cent.
Helium (He)	0.1 per cent.
Oxygen (O_2)	trace

B.t.u. per cubic foot, at a pressure corresponding to 29.82 in. of mercury and at 60 deg. F. = 887.3; specific gravity = 0.6135.

Heat Value

It was pointed out that the heat value of natural gas depends principally upon the relative proportions of methane, ethane, and the inert gases such as nitrogen and carbon dioxide. The only satisfactory method of ascertaining the heat value is by calorimetric determinations, but as this is not always convenient, the next best procedure is to compute it from the chemical analysis of the gas, using the value shown in Table 2 for the heat values of the constituent gases. This is done by multiplying the percentage of each gas by its corresponding heat value per cubic foot and adding the products. The specific gravity may be obtained in a similar manner.

It is sometimes desirable to obtain an approximate knowledge of the heating value of the gas when neither a calorimetric determination nor a chemical analysis is available. In such cases a close approximation may be made from the specific gravity of the gas, provided it is known to be a normally dry* gas without freakish tendencies.

The specific gravity may be determined readily by the "effusion" method, in which the time required to pass a given quantity of the gas through a pin-hole orifice in a thin plate, under a given pressure, is divided by the time required to pass the same quantity of air through the same orifice under the same pressure; the square of the quotient is the specific gravity of the gas referred to air. For most reliable results the gas and the air should be at the same temperature.

Mr. Weymouth gave an approximate formula for determining the heat value from the specific gravity of the gas. From the average analysis given in Table 1, it will be seen that of the combustible gases, methane and ethane, comprise 93.5 per cent. of the whole and ethylene and carbon monoxide comprise 0.2 per cent. each. No great error is made, therefore, if the two latter gases are considered as being part of the paraffin group, especially since ethylene and ethane do not differ greatly in either heat value or specific gravity. The inert gases may likewise be combined in one group, the resulting specific gravity of which may be considered equal to 1. Consequently, for approximate results the natural gas may be regarded as made up of three distinct gases, namely: methane, ethane and "inert" gases. Their respective heat values and specific gravities are as follows:

TABLE 2

	B.t.u. per Cu.Ft.	Sp.Gr.
Methane	897	0.5529
Ethane	1594	1.0368
Inert gases		1.0000

Representing the relative volumetric proportions of these gases, expressed decimally, as m, e and i respectively, the following relation will obtain:

$$m + e + i = 1.0 \quad (1)$$

$$H = 897\,m + 1594\,e \quad (2)$$

$$G = 0.5529\,m + 1.0368\,e + 1.0\,i \quad (3)$$

where

H = Lower heat value in B.t.u. per cubic foot of natural gas at 29.2 in. of mercury;

G = Specific gravity.

Combining equations 1, 2 and 3, the heat value may be found in terms of i and G as in equation (4).

$$H = 1440\,G - 1541\,i + 100.6 \quad (4)$$

The total of the percentages of the inert gases as shown in Table 1, is 6.1 per cent. or expressed decimally, 0.061. Substituting this in equation (4),

$$H = 1440\,G + 6.6 \quad (5)$$

Applying equation (5) to the average gas, as given by Table 1, in which the specific gravity is 0.6135, it would indicate a heat value of 890 B.t.u. The heat value as computed from analysis was 887.3, thus showing the approximation to be very close.

*By "dry" gas is meant that coming from a well producing gas exclusively as distinguished from that coming from an oil well, which is called "wet" gas. These terms have no reference to water vapor in the gas but imply the absence or presence of vapors of hydrogen higher in their respective series than those under consideration.

Some Exhaust Troubles

By James H. Beattie

Brooks is a gas-engine trouble man so much engrossed in the subject that the mere sound of the exhaust is sufficient to start him in its direction. He even claims that he can generally tell an engine's make from its exhaust.

Not long ago we were traveling together and had stopped for the night at a small country hotel. After supper we were sitting in front of the hotel when we heard what appeared to be the exhaust of a good-sized engine some distance away.

"Hello! that sounds like a B—— engine. I can tell them anywhere by the peculiar noise of the exhaust. Let us go over and see it," said Brooks.

"You know," he remarked, as we went along, "the B—— people use a peculiar type of hit-and-miss governor on their engines, and while they are all right for some purposes, the speed is so variable that they are wholly unsuited for work requiring close speed regulation. Notice from the sound of the exhaust that this engine takes five or six impulses, then cuts out almost as many. I'll venture that the speed of that engine is fluctuating 10 per cent."

From the sound we judged we were now close to the object of our search. "I guess it is in this yard," said Brooks; "just let me take a look over this board fence and I will see how we are to get in there." Brooks jumped up, and after

looking for a moment he got down with a rather foolish expression on his face.

"Well, how do we get in there?"

"I guess we don't want to get in," he replied.

I looked over the fence—and saw a husky darky industriously beating a carpet on a line. Every five or ten strokes he would change the beater from one hand to the other, and incidentally take a short rest.

After we had returned to the hotel Brooks told me several incidents about gas-engine exhausts and exhaust pipes, which led me to think that the exhaust of the internal-combustion engine is more important than most people believe.

"Last summer," began Brooks, "I was sent to a large summer resort where three of our vertical engines had been installed, to remedy some trouble with the exhaust valves burning and warping. The engines were of the three-cylinder type and the valves were not water-cooled. I found that they had connected the exhaust pipes of the three engines to a common header running the length of the engine room, then turning down the wall and passing through it into a muffling chamber outside the building. The header was large enough to carry the gases from all the engines, but it was only 3 ft. from the tops of the cylinders. The individual exhaust pipes from each cylinder were connected into the header with tees." Brooks then made the sketch, Fig. 1, to illustrate the arrangement.

He went on to explain that all the trouble was due to this arrangement of the exhaust pipes. The engines were of

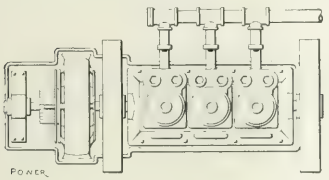


FIG. 1. PLAN VIEW SHOWING EXHAUST PIPE

100 hp. each and a large amount of hot gas passed out through the exhaust pipes. The flame was turned back by the tee on the header, and the trouble with the exhaust valves resulted. By rearranging the exhaust piping so that each engine had a separate exhaust header and that there were no sharp bends in the exhaust pipe, the trouble disappeared.

"In another case the trouble was due to another cause," continued Brooks. "The engine was small and had been installed by the purchaser to run a small mill. It operated all right for a time, then suddenly refused to carry its load. The engineer knew little about gas engines and was puzzled. I was sent from the factory to correct matters and found the engine apparently in good condition. The batteries were new and tested out all right; the ignition was properly timed, in fact, everything about the engine seemed to be in good condition, yet it would not develop enough power to run at normal speed even without a load.

"After close examination the trouble proved to be in the exhaust pipe. The engine was fitted with an exhaust chamber set on the floor near the engine, and the pipe from the engine should have entered the top of this chamber through a stuffing-box packed with asbestos. Instead, the man who had connected up

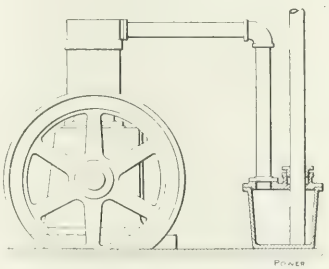


FIG. 2. OUTLET PIPE OF MUFFLER RESTING ON BOTTOM OF THE VESSEL

the pipes had reversed the connections so that the pipe from the engine was attached to the exhaust chamber by a flange and capscrews, and the pipe running through the roof was placed in the stuffing-box (Fig. 2).

"As a result, the weight of the long pipe through the roof had caused it to slide down until the end rested on the bottom of the vessel, leaving practically no exit for the exhaust gases."

One more incident related by Brooks showed the importance of the exhaust pipe. A shingle factory in Florida installed a 70-hp. single-cylinder engine several months ago. Not wishing to be annoyed by the noise of the exhaust, the superintendent had a muffling-box constructed outside the engine room. It was built of concrete and the 4-in. exhaust pipe was set solidly into it. As a result the expansion of the pipe sprung the studs holding the exhaust-valve casing, making it impossible to keep the packing from blowing out. They had continual trouble until the exhaust pipe was provided with a swing joint so that the pipe could expand and contract freely.

Comparative Costs with Producer Gas and Diesel Engine Plants

In a paper on power-plant operation delivered recently before the Dallas (Texas) chapter, N. A. S. E., Prof. A. C. Scott gave some interesting figures showing the comparative production costs between a 250-hp. Diesel engine plant operating in southwestern Texas and a 500-hp. producer-gas plant operating on Texas lignite 24 hours a day under a load factor of about 80 per cent. The comparative figures were as follows:

225-HP DIESEL ENGINE PLANT, 700,000 KW.-HR.

Investment		
Engine, compressor, piping, etc., installed (A)		$15,800
Generator, switchboard and wiring (B)		3,500
Building, cooling tower and tanks (C)		3,000
Total		$22,300
Fixed charges		
Interest at 6 per cent		$1,338
Insurance and taxes at 2 per cent		446
Amortization (A) at 4 per cent		632
Amortization (B) at 2 per cent		70
Amortization (C) at 1 per cent		30
Profit at 5 per cent. on the investment		1,115
Total		$3,631
Operating costs		
Crude oil, 1680 bbl. at $1.22 per barrel	$2,050	
Lubricating oil and waste	250	
Water	250	
Engineers	2,000	
Repairs	250	
Total		$4,800
Total costs for 700,000 kw.-hr.		$8,431
Cost per kilowatt-hour	$0 012	

500-HP PRODUCER GAS PLANT, 2,000,000 KW.-HR

Investment		
Producers (A)	$13,600	
Engine (B)	22,400	
Generator, switchboard, wiring, cooling tower (C)	10,600	
Building (D)	3,400	
	$50,000	
Fixed charges		
Interest at 6 per cent on $50,000	$3,000	
Insurance and taxes at 2 per cent	1,000	
Amortization (A) and (B), 1½ per cent	1,620	
Amortization (C), 2 per cent	212	
Amortization (D), 1 per cent	34	
Profit at 5 per cent on investment	2,500	
		$8,366
Operating costs		
Lignite, 3.7 lb. per kw.-hr., 3700 tons at $1.50	$5,550	
Lignite, standby losses, 300 tons at $1.50	450	
Engineers	3,300	
Producer men	3,000	
Oil and waste	350	
Water	160	
Repairs	250	
		$13,060
Total costs for 2,000,000 kw.-hr.		$21,426
Cost per kw.-hr.		$0 0102

It will be noted that if the load factor of the Diesel plant were increased to correspond with that of the producer-gas plant the kilowatt-hours delivered would be about 900,000 per year and the oil consumption approximately 1837 bbl. With the other operating costs as stated and the same fixed charges, this would make a total of $8621, or $0.0096 per kilowatt-hour.

[It would seem that Prof. Scott has assumed the amortization charges entirely too low.—EDITOR.]

"With the crank of an engine at half stroke, where is the piston?" said the examiner.

"Where the h——l would it be but in the cylinder?" the candidate retorted.

Refrigeration Department

Principles and operation of ice-making and refrigerating plant and machinery

Does Large Artificial Ice Storage Pay?

By R. P. Kehoe

This question is often raised and the following basis of calculation may assist those interested. The principal reason for considering large storage arises from the fact that the time of full production each year is limited; that is, the yearly load factor is low. This is true everywhere, except in very warm climates, and greatly influences the possible annual profit.

A large ice storage makes possible operating at full capacity throughout the year, but the storage building means a large additional investment and a maintenance expense that must be taken into account.

As an example, in a plant of 100 tons daily capacity, operated in the usual manner, an average yearly load factor of 50 per cent. is a safe basis; the full yearly capacity figured for 360 days being 36,000 tons. With a 50 per cent. load factor the actual yearly output would be 18,000 tons, this amount being distributed over the 12 months. The demand during the three hottest months would be the full capacity of 100 tons a day, dwindling down to a very small amount in the winter months.

It is assumed that such a plant is located where there is sufficient market for the full capacity in the summer months, which is only about three months or less, and must determine the size of the plant.

A plant of 60 tons daily capacity in conjunction with a large ice storage, may be made to take care of the same demand supplied by a 100-ton plant conducted in the usual manner. Table 1 indicates an average monthly production throughout the year in a 100-ton plant and how a 60-ton plant can be made to fill the same requirements.

The demand in various localities will differ and the monthly requirements may not correspond with the average figures which have been taken, but the relation between summer and winter production will in most cases be practically the same. Full capacity can be maintained during the fall and early winter in order to shut down the plant for a month or more for a thorough overhauling and to install repair parts and improvements. The small amount of ice in storage will probably not need refrigeration, as the outside temperature will be comparatively low at this time. If absolutely essential, a small auxiliary refrigerating machine can be included in the equipment to maintain the storage when the main unit is shut down for repairs. This auxiliary unit may be operated by motor or other available power, but in all probability it will not be required.

The last column indicates a proposed schedule of operation for the 60-ton plant to produce a yearly output of 18,000 tons and meet the same demand as a 100-ton plant. The full capacity is maintained for ten months, leaving two months for overhauling, improvements, etc. The excess amount produced in October and November will supply the demand in December and January. Only about 1350 tons are in storage when the plant is shut down, this small amount losing only a slight percentage from melting during the cold season.

Since the ice-making machine must be large enough to care for the entire storage and manufacture at full capacity in the summer months, the normal capacity will be exceeded in the cooler seasons. This is especially true when little or no ice is stored. The schedule of operation does not take this into consideration and some leeway is therefore represented.

To arrange a plant to operate at full load for 10 months instead of six is good business practice if the increase in cost of operation, depreciation and investment is not too great. The additional cost is not large, being confined to the extra fuel required for supplying the refrigeration to maintain the ice storage. Depreciation will also increase to some extent, but the most important item is the cost of the storage building. This really seems to decide the question, for if the first investment is increased too much, it would be better to build a 100-ton plant with only the usual daily storage.

The most favorable conditions for large storage are obviously a low yearly load factor and cheap building materials. The cost of brick buildings in large cities would be very unfavorable and the load factor high. Under these circumstances the machinery is idle only a short time each year and there is no crying need to spread the production over a greater length of time. The calculations are therefore based on a wood structure with inexpensive insulation and a 50 per cent. yearly load factor. Tables 2 and 3 show how a proper comparison may be made.

TABLE 2. 100-TON ICE-MAKING PLANT—SIMPLE CAN SYSTEM

Investment	
Complete mechanical equipment	$54,000
Building and foundations	30,000
Total investment	$84,000
Daily Operating Expense	
16 tons of coal at $3.50	$56 00
One chief engineer	5 00
One night engineer	3 50
Two firemen at $2	4 00
Four tankmen at $2	8 00
Two laborers or storehousemen at $2	4 00
Two oilers at $2	4 00
Ammonia, oil, waste and supplies, etc.	10 00
Office man	4 00
	$98 50
Depreciation, etc.	
5% depreciation on machinery ($54,000)	$2,700 00
2% depreciation on building, etc. ($30,000)	600 00
Repairs, taxes, water and incidentals (5%)	4,200 00
	$7,500 00
Summary	
180 days' full operation at $98.50	$17,730 00
Labor for balance of year, leaving out only two laborers = 180 days at $28.50	4,845 00
Depreciation, etc.	7,500 00
	$30,075 00
Income from sale of 18,000 tons of ice at $2.50	45,000 00
Profit $45,000 — $30,075 = $14,925 = 17.8%	

A storage space large enough for 5000 tons of ice has been figured to be safe and give ample room for handling the

TABLE 1. 60-TON PLANT AND STORAGE DOING WORK OF 100-TON PLANT

Month	Approx. Average Output in Tons of 100-Ton Plant to Supply Usual Demand		With 60-Ton Plant Excess Which Must be Supplied from Storage	Proposed Time of Production for Storage Purposes	Proposed Schedule of 60-Ton Plant to Meet Usual Demand of 100-Ton Plant
	Daily	Monthly	Monthly	Monthly	Monthly
January	15	450	....	150	*
February	10	300	....	1500	1800
March	25	750	....	1050	1800
April	25	750	....	1050	1800
May	50	1500	....	300	1800
June	100	3000	1200	...	1800
July	100	3000	1200	....	1800
August	100	3000	1200	....	1800
September	75	2250	450	....	1800
October	50	1500	.	....	1800
November	25	750			1800
December	25	750			*
Totals		18,000	4050	4050	18,000

*Overhauling and repairs

ice; 50 cu.ft. per ton should be quite sufficient. This space could be about 200 ft. long by 100 ft. wide and 12½ ft. high, and the total wall, floor and ceiling surfaces aggregate 47,500 sq.ft. A heat leakage of 5 B.t.u. per square foot per degree difference in temperature every 24 hours is a conservative estimate, and the refrigerating work would be

$$\frac{47{,}500 \times 5 \times 50}{288{,}000} = 40 \text{ tons}$$

The average temperature difference between the outside and the interior of the storage has been estimated as 50. Calculating that each square foot of pipe surface will absorb 50 B.t.u. per degree difference in temperature every 24 hours and assuming a back pressure of 15 lb. equivalent to an ammonia temperature of 0 deg. F. (equals a temperature difference of about 30 deg.), the amount of 2-in. piping required for the storage would be

$$\frac{47{,}500 \times 5 \times 50 \times 1.6}{30 \times 50} = 12{,}667 \text{ ft.}$$

or in even numbers 12,600 ft. The approximate cost of this piping would be $5000 erected in place.

The depreciation, repairs, etc., have been increased in the 60-ton plant to 6 per cent. as compared with 5 per cent. in the 100-ton plant. This is quite fair since the apparatus will have to run 66⅔ per cent. more of the time each year.

Notwithstanding that the 60-ton plant has been favored as much as possible, the yearly profit is $1000 less and the percentage of earnings to investment is very little more. If the cost of the storage building should be somewhat higher, the 100-ton plant would make a still better showing. The figures indicate how important it is to study each situation carefully to determine the best combination. Exact estimates should always be procured covering equipment and buildings, and if the same method is followed no difficulty will be had in obtaining the correct solution.

It is sometimes claimed that a plate ice plant is best because artificial ice produced by this method can be safely stored without refrigeration. Plate ice undoubtedly will look better than can ice when stored for any length of time without refrigeration, and it is very difficult to keep the latter from freezing together because the cakes are so even, but it is doubtful if it pays to thus store manufactured ice. The writer has never seen any accurate figures showing percentage of meltage and cost of refrigerating a storage; the latter can be estimated, but it is almost impossible to calculate the former.

It can be asserted that a plate plant and large ice storage will show a good profit, not so much on saving the expense of refrigerating the storage, but by virtue of the higher economy which is taken advantage of throughout almost the entire year. Using the same method as the former tabulations, the plate plant is figured out in Table 4.

TABLE 3. 60-TON ICE-MAKING PLANT SIMPLE CAN SYSTEM

(With 5000 tons ice storage)

Investment	
Complete mechanical equipment	$40,000
Building and foundations	35,000
Total investment	$75,000
Daily Operating Expense (For 60 tons ice production)	
10 tons of coal at $3.50	$35 00
One chief engineer	5 00
One night engineer	3 50
Two firemen at $2	4 00
Two tankmen at $2	4 00
Two laborers or storehousemen at $2	4 00
Ammonia, oil, waste and supplies, etc.	7 50
Office man	4 00
	$67 00
Ice Storage	
Entire refrigerating work = 40 tons, requiring 3 tons of coal at $3.50	$10 50
Depreciation, etc.	
6% depreciation on machinery ($40,000)	$2,400 00
2% depreciation on building, etc. ($35,000)	700 00
Repairs, taxes, water and incidentals (6%)	4,500 00
	$7,600 00
Summary	
10 months' full operation, 300 days at $67.00	$20,100 00
Carrying full ice storage for about 6 months, 180 days at $10.50	1,890 00
All labor during two months' shutdown, 60 days at $24.50	1,470 00
Depreciation, etc.	7,600 00
	$31,060.00
Income from sale of 18,000 tons of ice at $2.50	45,000.00
Profit	$45,000 — $31,060 = $13,940 = 18.6%

TABLE 4 60-TON ICE-MAKING PLANT— PLATE SYSTEM

(Compound condensing steam engine. 5000 tons ice storage)	
Complete mechanical equipment	$60,000 00
Building and foundations	40,000 00
	$100,000 00
Daily operating expense (For 60 tons ice production)	
5 tons of coal at $3.50	$17 50
One chief engineer	5 00
One night engineer	3 50
Two firemen at $2	4 00
Two harvesters at $2	4 00
Ammonia, oil, waste, supplies, etc	7 50
	$41 50
Depreciation, etc.	
6% depreciation on machinery ($60,000)	$3,600 00
2% depreciation on building ($40,000)	800 00
Repairs, taxes, water and incidentals (6%)	6,000 00
	$10,400.00
Summary	
10 months' full operation, 300 days at $41.50	$12,450 00
All labor during two months' shutdown, 60 days at $16.50	990 00
Depreciation	10,400 00
	$23,840.00
Income from sale of 17,000 tons of ice (assuming loss of 1000 tons through meltage) at $2.50	42,500.00
Profit	$42,500 — $23,840 = $18,660 = 18.66%

Table 5 gives a summary of the three tabulations, which will be of assistance in making a comparison.

The only conclusion which can be drawn from these figures is that there is very little difference between the three propositions as an investment, and a careful and accurate estimate must be made in every instance to determine which plant will prove the best.

Trouble from Frost

A correspondent recently asked the question printed below, and the reply following may be of interest to engineers experiencing similar trouble.

Of two vertical, single-acting inclosed crank-case ammonia compressors, one gives trouble by frosting all over the base of the crank case and the water jacket, while the other does not frost at all. A ¾-in. line with a valve connects the base of the compressor which frosts to the suction line. The valve is left open to prevent the accumulation of pressure in the crank case from forcing the oil out through the shaft stuffing-box. If the box is turned tight enough to prevent this it heats. The frost melts off when the valve is closed. What causes the trouble; does the high-pressure gas get by the piston into the base?

It would appear that liquid ammonia is entering the base of the frosting compressor through the line connecting the base to the suction line. This would rarely happen if the connection is made into the bottom of the line and the system is so operated that the suction line frosts back heavily at the point where the connection is made. A small amount of liquid ammonia is sufficient to frost the base of a machine for a long time as the absorption of heat through the heavy cast-iron walls is slow and the coating of frost offers still further resistance.

The necessity of running with the valve in the connecting line open is probably due to leakage of the high-pressure gas past the piston into the base. A new set of piston rings carefully fitted will probably remedy the trouble.

If the other compressor cannot be made to frost it may be due to the suction line to this compressor offering more resistance to the passage of the return gas. If the stuffing-box continues to heat after the piston has been made tight, insert behind the last ring of packing a thin split ring made of cast iron with a groove turned on the inside to form a small

TABLE 5. SUMMARY OF COST FIGURES

	Investment	Daily Operating Expense	Total Yearly Expense	Estimated Profit	Percentage of Profit to Investment
100-ton can ice-making plant	$81,000	$98.50	$30,075	$14,925	17.8
60-ton can ice-making plant and 5000 tons ice storage, refrigerated	75,000	67.00	31,060	13,940	18.6
60-ton plate ice-making plant and 5000 tons ice storage, not refrigerated	100,000	41.50	23,840	18,660	18.66

off pocket or miniature "lantern." Make the bore of the ring just large enough so as not to score the shaft. The ring should make a snug fit on the inside of the stuffing-box.

Measurement of Frigorific Power*

Countries using the metric system express the power of a refrigerating machine by the number of frigories which that machine can produce in one hour, under given conditions of evaporation and of condensation. The power of machines is also often expressed by the number of kilograms of ice they are able to manufacture in the course of one hour's work.

English-speaking countries express the power of machines by frigorific tons per 24 hours; that unit measures the quantity of refrigeration necessary to freeze one ton of water without changing its temperature; that is, the water being taken and frozen at 0 deg. C. However, the British or long ton being somewhat different from the American or short ton, the result is that units of power in the two countries are not alike.

The United States also uses another unit: the efficiency of machines is sometimes estimated in gallons-degrees per minute, a unit measuring the quantity of refrigeration necessary to lower by 1 deg. F. the temperature of 1 gal. of water taken at 33 deg. F.

The concordance between these various units is shown in the accompanying table.

*From bulletin of the International Association of Refrigeration.

MEASUREMENT OF THE POWER OF A REFRIGERATING MACHINE ACCORDING TO THE VARIOUS SYSTEMS

Frigories-hour	British Frigorific, Ton per 24 hr.	American Frigorific, Ton per 24 hr.	Gallons-Degrees per minute
100	0 030	0 033	0 907
200	0 059	0 066	1.814
300	0 089	0 099	2.721
400	0 118	0 132	3.628
500	0 148	0.165	4.535
600	0 177	0.198	5.442
700	0 207	0.231	6.349
800	0 236	0 264	7.256
900	0 266	0.298	8.163
1,000	0 295	0 331	9.070
2,000	0 590	0 661	18.014
3,000	0 886	0.992	28.21
4,000	1.181	1 324	36 28
5,000	1.476	1.655	45.35
6,000	1.772	1.986	54.42
7,000	2.067	2 314	63.49
8,000	2.362	2.647	72.56
9,000	2.657	2.975	81.63
10,000	2.959	3.306	90.70
12,000	3.549	3 972	108 84
15,000	4.428	4.961	136.05
18,000	5.314	5.950	163 26
20,000	5.904	6.612	181.4
25,000	7.380	8.275	226.7
30,000	8 856	9.917	272.1
35,000	10 34	11 57	317.5
40,000	11.81	13 24	362.8
45,000	13.29	14.90	408 2
50,000	14.76	16.55	453.0
55,000	16.24	18.19	499.0
60,000	17.72	19.86	544.0
65,000	19.19	21.49	590.0
70,000	20.67	23.13	635.0
75,000	22.14	24.80	680
80,000	23 62	26.47	726
85,000	25.09	27.73	771
90,000	26 57	29.76	816
95,000	28 05	31.42	862
100,000	29.52	33.06	907
110,000	32 47	36 37	998
120,000	35.43	39.72	1,088
130,000	38 38	42 98	1,179
140,000	41 33	46 26	1,290
150,000	44 28	49 59	1,361
160,000	47.23	52 93	1,452
170,000	50.18	55 46	1,542
180,000	53.13	59 50	1,632
190,000	56 09	62 84	1,723
200,000	59 04	66 11	1,814
210,000	61.99	69 43	1,905
220,000	64.94	72 74	1,996
230,000	67 89	76 05	2,086
240,000	70.85	79 44	2,176
250,000	73 80	82 64	2,267
260,000	76.75	85 96	2,357
270,000	79 70	89 27	2,448
280,000	82 66	92 52	2,540
290,000	85 61	95 85	2,630
300,000	88 56	99.18	2,722
400,000	118.08	132 22	3,628
500,000	147 60	165 28	4,534
1,000,000	295 20	330.56	9,068
2,000,000	590 40	661.12	18,136
3,000,000	885 60	991.68	27,204
4,000,000	1,180 80	1,232 24	36,272
5,000,000	1,476.00	1,652 80	46,340

Drawing Ammonia from Compression System

In a recent issue of POWER, Mr. McGerry illustrates and describes a method of removing ammonia from the piping system of a compression-refrigerating or ice-making plant, and storing it in an empty drum. It is poor practice to attempt to remove liquid ammonia from the system connecting the empty drum to the highest point of the receiver; the proper place for such a connection is at the drain valve on the bottom of the receiver.

As a rule, the liquid receiver is set high enough above the floor level to be over the inlet connection on the empty ammonia drum when it is placed on a pair of platform scales. In the sketch the empty drum is shown connected differently.

To remove the charge, operate the compressor slowly, allowing condensing water to circulate freely over the ammonia condenser. See that the inlet valve *A* on the ammonia receiver is open, allowing the liquid ammonia to flow from the ammonia condenser into the liquid receiver. Next open the valve on the empty ammonia drum, then open the drain valve *D* and let the liquid ammonia flow into the empty drum. The charging valve *C* should also be opened and when the line connecting the liquid receiver and empty drum becomes gas-bound, valve *B* on the line to the charging valve can be opened for an instant, allowing the compressor to relieve the gas-bound line.

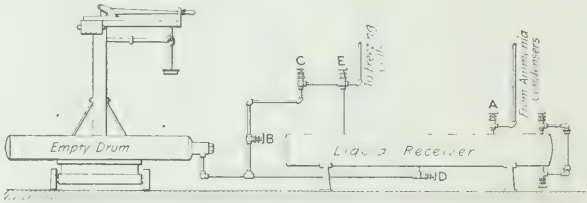
In cases where there is no charging connection at the liquid receiver, the relief line may be carried to the ammonia suction line or left open to the atmosphere. In hotels or office buildings, the last mentioned plan could not be used, as ammonia cannot be permitted to escape to the open air.

It is understood, of course, that the outlet valve *E* on the liquid receiver is closed, the gas released at valve *B* passing above the seat of valve *E* and on through the line to either the freezing or direct-expansion coils, and finally back to the compressor, where it is again discharged to the condensers and condensed to liquid form.

It is important when filling empty drums to watch the scales closely so that the drums are not filled too full.

THOMAS BAKER.

New York City.



PIPING CONNECTIONS FOR REMOVING AMMONIA

Wear in Ammonia Compressor Cylinder

I would like to have readers of POWER explain why a horizontal ammonia-compressor cylinder wears more at the top than on the bottom surface of the cylinder. For several years I have noticed in overhauling and reboring horizontal ammonia-compressor cylinders that the most wear seems to be on the top surface of the cylinder irrespective of the location of the suction or discharge valves. Some machines have suction valves on top and some have the discharge, but both develop the same peculiar wear in the cylinder.

C. E. ANDERSON.

Chicago, Ill.

Compressed Air from Ammonia Compressor

In our plant we have no air compressor and as we have a number of motors which require frequent cleaning as they are located in dirty places, we have been compressing the air for this purpose with the ammonia compressor. The ammonia was first worked out of the cylinder; the discharge valves were then closed and the purge valves opened. The suction-purge plugs were then removed and air under pressure turned on to the motors.

MARTIN MCGERRY.

Holley, N. Y.

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROBT. MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication.

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue, 29,000 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

A New Analysis of Indicator Diagrams

An indicator diagram gives the pressure of steam with which the cylinder was filled at any point in the stroke. Knowing the volume of the cylinder up to the chosen point and the number of times it is filled per hour, it is easy to compute, if the point chosen is after cut-off takes place, the volume of steam of the indicated pressure passing through the engine per hour.

If the contents of the cylinder were all dry-saturated steam, the weight per cubic foot could be taken from the steam tables and the weight of steam used per hour determined, but a considerable quantity of water is present, caused by condensation upon the containing surfaces, and any determination based upon the assumption that the steam is dry saturated will be from fifteen to fifty per cent. in error.

As the pressure is lowered by expansion a portion of the water is evaporated so that the expansion line, instead of falling off as rapidly as it would if only a constant weight of steam were acting, is kept up until the curve resembles the isothermal or constant temperature curve of a perfect gas.

It is natural to suppose that the form of the curve would be influenced by the amount of heated water present at the commencement of expansion, and Paul J. Clayton, of the engineering-experimental station of the University of Illinois, in a remarkable paper presented to the American Society of Mechanical Engineers and abstracted on page 858, shows that this is so. A large number of indicator diagrams were replotted upon logarithmically ruled paper, and unless the conditions under which they were taken were abnormal, the expansion and compression curves became straight lines, but with different inclinations for different diagrams.

The most significant fact brought out by Mr. Clayton is that there is a definite relation between the inclination of the expansion curve so plotted and the quality of the steam; that is, the amount of moisture present at the commencement of expansion.

If this relation can be determined with precision, the engineer will have at his command an easy way to determine, with just the same degree of precision, the water rate of his engine simply by taking a diagram from it. An engine, instead of having its performance determined once in its lifetime by a laborious and expensive test, can be kept under constant surveillance, any increase in its steam consumption detected and the cause removed. The size of the engine appears to have little effect upon this relation; speed has some effect and pressure more.

Mr. Clayton has evolved such a statement of the relation as to enable one to calculate the water rate for the ordinary case with an average difference of some four per cent. between the calculated results and those obtained by weighing the exhaust. It is likely that the analysis of a larger number of diagrams and a study of the conditions under which they were taken will result in a formula or set of diagrams which will give still more accurate results for a case of which all the conditions are known, and the greatest service which an engineer who has access to diagrams taken while the water rate was being measured can perform for steam engineering is to either plot these diagrams himself or send them to Mr. Clayton or to POWER with a complete statement of the significant conditions.

Besides determining the water rate, the new method of analysis indicates much more positively than does the original diagram, leakage into or out of the cylinder and affords means of definitely determining the clearance. It is applicable to diagrams from internal-combustion engines, air and ammonia compressors, etc., as well as to those from the steam engine.

We heartily recommend the reading of the abstract on page 858 and urge the reader to try the analysis in his own practice and report results. Logarithmically ruled paper may be obtained from any dealer in draftsman's supplies and

copies of the complete paper may be had upon application to the secretary of the American Society of Mechanical Engineers, 29 West Thirty-ninth St., New York.

Prof. Clayton has shown that by replotting an indicator diagram upon logarithmically ruled paper a number of points are brought out that the original diagram fails to show. It remains now for somebody to invent a logarithmic reducing motion and pencil movement so that one can take the logarithmic diagrams right from the cylinder and proceed to analyze without all the trouble of replotting.

Depreciation and Obsolescence

A steam plant uses up something besides coal and oil and waste and water. It uses up boilers and engines and pumps and apparatus. When, therefore, one computes the cost of making power he must take into account not only the fuel and water and wages and small supplies but the plant which is being used up and is depreciating in value from year to year.

From the point of view of reconvertibility into hard cash a large depreciation takes place at the start. An engine which has been run ever so little cannot be sold for anything like what it cost set up and ready to run. But it is usual to assume that the business will continue throughout the life of the engine and to charge each year's expenses with an equal proportion of its cost. Supposing a plant will last twenty years there would be added to the actual current expenditures of each year one-twentieth, or five per cent. of the cost of the plant in making up the cost of power production. This is depreciation. The amount thus reserved from the profits is, theoretically at least, set aside for the purchase of new apparatus as the old is used up. The amount thus set aside from year to year is capable of earning interest, and if credited with compound interest, a considerably less percentage need be charged off each year.

The purpose of the account is likely to make a difference in the method of handling this item. A public-service corporation should not be allowed to use it as a means of swelling the cost for purposes of rate fixing, and then not apply it to its avowed purpose. If at the end of the usefulness of the plant the capital or investment fund upon which interest and profits are to be earned is credited with the investment for the new it should be charged with what has been collected for depreciation upon the old.

But it may happen that long before the machinery is worn out it may be rendered obsolete by the invention or development of something which is so much better that its owner cannot afford to continue to use it. This obsolescence or the likelihood of it should not be allowed to be mixed up with depreciation. The old plant will make good on the basis of the original estimate. It will cost no more to run it than it was expected that it would because there has been something found later which will run more economically. The new thing must be so much better that it will pay for the sacrifice, the obsolescence, of the old. In case it will do this the investment account should be credited with the amount invested in the new machinery and charged with the depreciation already collected upon that which it displaces together with whatever the old may bring if disposed of. This will leave the uncollected portion of the original cost of the old apparatus in the capital or investment account to go on collecting depreciation until the original cost of the old apparatus has been wiped out, when it should cease so far as that investment is concerned.

Action between Ash and Firebrick

E. G. Bailey, combustion engineer, of Boston, brought out a point in a recent lecture to the Institute of Operating Engineers in New York. The trend of boiler practice has been in the direction of getting greater evaporation from a given amount of heating surface. The old idea that economy lay in large ratios of heating to grate surface, in having a lot of water-cooled surface to absorb the heat from the gases, in burning coal at moderate rates of combustion has been discounted by engineers who had to run their boilers for all that there was in them to get over a peak, and who found that the loss of efficiency when running under these forced conditions was surprisingly small.

It develops that, whether or not it pays to run boilers at considerably over 3 pounds of evaporation per square foot of grate surface with deliberate intent and as a regular practice, it is cheaper to double this rate during the few hours of excessive demand than to keep a large reserve of extra boilers with banked fires standing the greater part of the time for use only under peak-load conditions. Furthermore, it has been found that a better control of furnace conditions is possible with a lively rate of combustion than when the fire is simply allowed to mull and the boiler to stew.

The limit to progress in this direction has been set not by the capacity of the boiler to absorb the heat, but by the ability of the furnace to stand it. It is a question of how much firebrick one can afford to burn; how often he can afford to replace furnace walls and arches. The country has been scoured for furnace material which will stay put with these high rates of combustion.

Mr. Bailey has previously called attention forcibly to the important relation of the fusing point of the ash to the clinkering properties of the coal. Clinker is simply melted ash. An ash which melts at a low temperature will clinker easily and have a more prejudicial effect upon the actual practical value of the coal than a much larger percentage of ash which will not fuse but will work itself out of the fire in the powdery form and allow the firing to go on uninterruptedly and with infrequent cleaning.

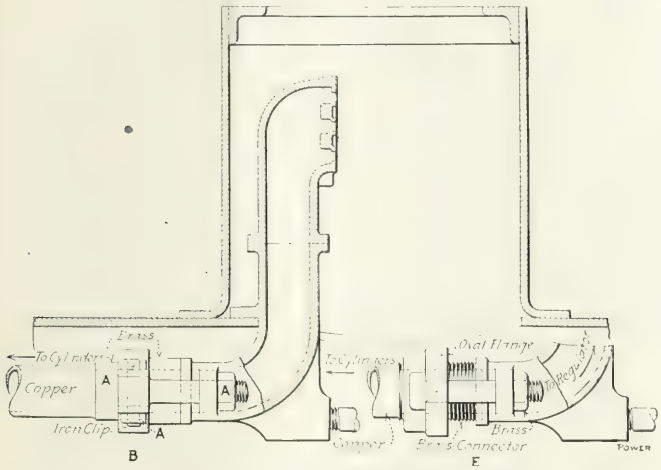
He now shows that the chemical constitution of the ash has an important influence upon the fusibility of the firebrick. Certain constituents of ash act upon certain clays in the same way that the flux put into a cupola for the purpose reduces the fusibility of its contents. In one case, for instance, where they were having trouble with the furnace linings, the fusing temperature of the firebrick was found to be 3100 degrees and that of the ash 2600 degrees, but combined they fused at 2400 degrees. The ash from other coals would not have produced this effect upon this particular brick, and other brick might have been used with this same ash without having its melting point so materially affected. It would seem as though there were an interesting line of investigation here, which promises to have an important bearing upon a power-plant problem of very pressing interest.

Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Internal Steam Pipe Design

The usual design of internal steam pipes on locomotive boilers is shown at *B* in the illustration. The removal or repair of such pipes when broken as shown is very difficult, especially when the tubes are in the boiler. The nuts *A* are gen-



INTERNAL STEAM PIPE OF LOCOMOTIVE BOILER

erally rusted fast to the ring and have to be split before they can be removed.

To avoid such trouble I designed the arrangement shown at *E*. A cast-iron oval flange with a copper screw connector is used to avoid the action of rust. The clip bolts are done away with and long bolts used instead. The nuts are brass and easy to remove.

A. L. HAAS.

London, England.

Why Did the Blowoff Pipe Get Red Hot?

In a lumber mill steam is furnished by a new horizontal return-tubular boiler 6½x18 ft.; the fuel is sawdust. The boiler was ordered in commission but the cast-iron protection sleeve for the blowoff pipe had not arrived. As there were no firebricks to protect the blowoff pipe, the chief placed a piece of old steel rail in front of it so as to break at least part of the flames.

Everything went well for about two hours, when the chief suddenly startled me, saying: "The blowoff is red hot!" We at once reduced the steam pressure to 40 lb. and carefully opened the blowoff valve. After a little spitting the water appeared, carrying before it a powdery substance. As soon as the water began to flow, the pipe cooled off. The chief then partially closed the valve to permit a small amount of water to run through all the time, thus keeping the pipe cool. The pressure was again raised and everything going in less than 20 minutes.

How did the pipe get red hot, if it was full of water? Will some reader inform me the best way to draw a sawdust fire?

PAUL HANNEMANN.

Passadumkeag, Maine.

Corliss Engine Diagrams

The diagrams in Figs. 1 and 2 were taken from an old crab-claw single-eccentric Corliss engine; Fig. 1 was taken under normal running conditions, and Fig. 2 with a back pressure of 12 lb. added to the normal conditions.

Fig. 2 is peculiar in that it was taken from a single-eccentric engine with lap on the steam valves, and the eccentric set at 90 deg. ahead of the crank. It seems to me that cutoff should have occurred at one-half stroke. I believe that, due to the additional load, the engine attempted to hold the cutoff until the end of the stroke, but because of dull toes on the crab-claw it fell off at this point, but why it should cut off just when the mean effective pressure equaled that of Fig. 1, I should like explained.

Fig. 3 was taken from a modern Corliss engine. I tied up the catch block

FIG. 1

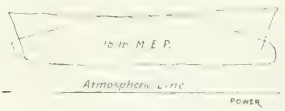


FIG. 2

on one end so that the other would have to do all the work. The result shown by the dotted line is a mean effective pressure of 42 lb., the total of that of both the head and crank ends.

FIG. 3

FIG. 4

Fig. 4 shows a card taken from the above engine while starting and until normal speed and cutoff were reached.

A. C. WALDRON.

Revere, Mass.

Silencing a Noisy Valve Gear

Recently a friend requested that I suggest a cure for a noisy valve-gear on his Corliss engine. I found that the links were nicely adjusted, the leather cushions on the latches were of sufficient thickness, and I was about to pronounce the gear in excellent condition when he informed me that when running the valve stems moved vertically for quite a perceptible distance.

Further examination showed that the hubs of the brackets were considerably worn, and that the valve stems were worn flat on the top and bottom; the oil holes leading to the stem were also plugged solid.

We turned down the stems to round

them properly. As there was plenty of stock in the bracket we bored it larger by ⅜ in., after which we cut a slot for its entire length. A piece of shafting a trifle smaller than the valve stem was then centered in it, after which babbitt metal was poured into the circular space. The hole was then bored to the required size and the oil holes drilled out. A groove connecting the holes was then made and the parts reassembled. The engine now runs smoothly and without noise.

LEIGHTON JOHNSON.

Exeter, N. H.

Comment on These Diagrams

The indicator diagram, Fig. 1, was taken from the high-pressure cylinder of a 24 and 34 by 48-in. cross-compound condensing Corliss engine running under at 60 r.p.m., and belted to a 500-ton refrigerating machine. Fig. 2 was taken from the low-pressure cylinder.

FIG. 1

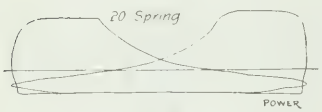


FIG. 2

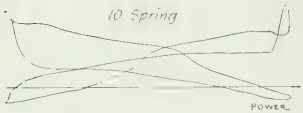


FIG. 3

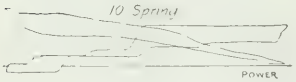


FIG. 4

FIG. 5

FIG. 6

AIR CYLINDER DIAGRAM

The boiler pressure was 145 lb., receiver pressure 20 lb. and 24 in. of vacuum obtained while taking the diagrams.

Figs. 3 and 4 were taken from the low-pressure cylinder of a tandem-compound noncondensing engine, running under at 90 r.p.m. Fig. 5 was taken from the 24x48-in. steam cylinder of an air compressor, with the air cylinder tandem-coupled to the steam cylinder. The engine is noncondensing, using steam at 150 lb. and running at 50 r.p.m. Fig. 6 was taken from the air cylinder of the above engine, the air pressure being 75 lb. Will interested readers comment on these diagrams?

C. E. ANDERSON.

Chicago, Ill.

Taking Steam from Water Column Connections

Fig. 1 illustrates the water column and connections as found in a certain plant. They are made with 1¼-in. pipe and valves, but a reducing tee was used in the upper connection. A ¾-in. outlet is thus provided, which branches in two directions. One of them is connected to the damper regulator, and as steam is not drawn through it no harm is done, but the principle is wrong. The other supplies a machine that takes enough to reduce pressure in the 1¼-in. connection; hence when only a partial load is carried, the water in the gage-glass rises and falls, proving that the indication is not reliable. On full load the water goes out of sight in the glass, and some of it mingles with the outgoing steam. This is not only dangerous, because it shows a false water-level, but very wet steam is supplied to operate the machine.

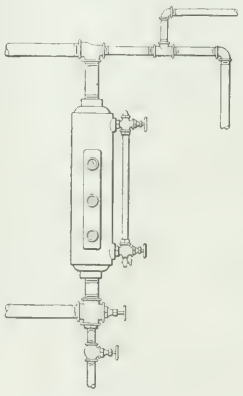


FIG. 1.

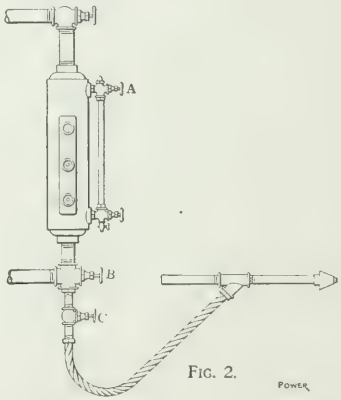


FIG. 2.

WATER COLUMN CONNECTIONS

Fig. 2 shows another water column with suitable connections. The engineer used the drip pipe to supply steam for the tube blower. Having connected it as shown, he opened *A*, closed *B* and opened *C*. After all water was drained from the column and pipes, dry steam was secured for cleaning the tubes. If this is done when the fire is banked, no special harm results, but where a boiler is not heavily loaded, it is practicable to clean the tubes while the engine is running rather than either before or after the regular working day. During this time it is impossible to know how much water is in the boiler, which is bad practice.

A safe rule is, never connect anything into water-column connections except the water column.

W. H. WAKEMAN.

New Haven, Conn.

Mismanaging Fires

The head fireman of a certain plant had an assistant who wanted to do things right, but the former would not let him; the assistant seemed the better man of the two. On a visit to the plant I found an opportunity to give him the advice an older man could give to a younger one. In a short while the assistant fireman was in full charge and the other fellow had gone.

The new man had the defective grates removed and a new set put in. The other fireman had piled coal into the furnace any way that was most convenient, but the new man put the coal in evenly and maintained a bed about 8 in. thick. By attending to his work he soon had the confidence of his chief engineer.

In another case I found a fireman operating with grate bars that had been heated excessively in the past and the weight of the coal had caused them to settle. The engineer and the fireman repeatedly asked the management for a new grate which was promised many times but never arrived. One day a new fireman came on the job, and as he was a good talker and had the backing of the engineer, he got the manager to order a new grate. It often happens that

managers will not take the advice of the old employees, but will take the word of a new man without question.

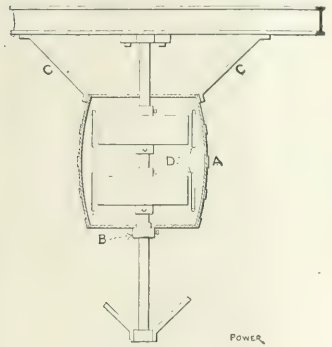
In another place the grate bars were in order, but the fireman had 14 in. of fuel heaped like a camel's back in the center. He soon lost his job. On the arrival of an expert the plant was shut down for 20 hours to put everything in order. Then a likely young fireman who had worked about the boiler room was given instructions in firing; the new man pulled through all right.

GEORGE RICE.

Melrose Highlands, Mass.

Novel Oil Baffler

A mule pulley in the finishing room of our plant threw an oil spray which damaged the stock and machines and made it unpleasant for the operatives.



BARREL OIL BAFFLER

To correct the evil I placed a flour barrel, *A*, around the pulley as shown in the illustration. The barrel was thoroughly reinforced throughout and a hole bored in the bottom to the size of the shaft. The braces were removed from the bottom of the shaft and the barrel slipped over the pulley into position. A collar *B* was fastened on the shaft to support the barrel, and braces *C* to the top of the barrel and I-beam for the same purpose. Slits *D* were cut in the barrel for the belt.

The device was a success as it has been in service for two months and prevents the oil from doing further damage.

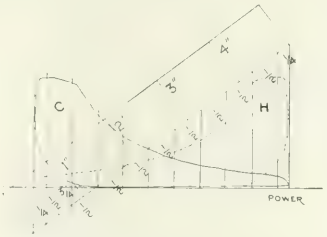
PETER VANDENBERG.

Paterson, N. J.

Doing without a Planimeter

For those engineers who do not use a planimeter, the following is a quick though an old way to divide a card into ordinates:

The cards should be about 4 in. long; if shorter, the end lines must be continued on a sheet of paper beneath the card. Along the atmospheric line place a square and draw a line perpendicular to the atmospheric line at each end of the card. Next place a rule diagonally across the card, as shown in the illustration, putting one end on one of the vertical lines and having the 5-in. mark touching the other.



POSITION OF SCALE FOR OBTAINING ORDINATES

Starting from either end, first mark off ¼ in. and then every ½ in.; this leaves a ¼-in. space at the other end. By placing the square on the atmospheric line again and drawing vertical lines through these points, the card will be divided into 10 equal parts. Adding the lengths of the ordinates and dividing by 10, and multiplying the quotient by the scale of the spring will give the mean effective pressure. The sum of the mean effective pressure of both cards divided by 2 gives the mean effective pressure to use in working out the horsepower of the engine.

JAMES A. CAMPBELL.

Providence, R. I.

Replacing a Tube Header

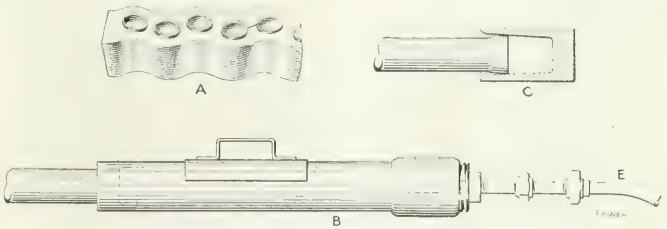
A tube header of the Babcock & Wilcox type cracked, as shown at *A*, in the illustration. As all the tubes were practically new it was decided to remove the header without disturbing the tubes in the header at the opposite end. Each was temporarily blocked to retain its original position and small holes were drilled in the header between the tubes. By driving drifts and chisels into these holes, the header was easily broken and removed.

The expanded ends of the tubes were then reduced by heating in a home-made forge, shown at *B*. This forge was made of old pipe and fittings, and a charcoal fire supplied with compressed air through the hose *E* gave good results. The forge was placed over the tube ends until they were heated to a cherry red, after which they were drawn by placing the tool *C* over their ends and hammering it. This tool tapers very slightly and by using a coarse taper in starting and a slight one in finishing, the work can be more quickly done.

Each tube was drawn to a ring gage of the original diameter of the tube, then the new header was placed over the tubes which were expanded in the usual manner. The opposite ends did not need rerolling. This process took less time than cutting out the tubes and replacing them and both headers.

A. M. QUINN.

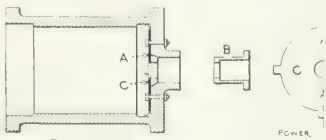
Canton, Ohio.



SECTION OF CRACKED HEADER, IMPROVISED FORGE AND REDUCING TOOL

Repair to an Engine Cylinder

While in charge of the machinery of a steamboat on the Great Lakes, where the continuous operation of the dynamo engine is important because the signal light must be bright, the dynamo engine blew out the shoulder in the stuffing-box as shown at *A*, permitting the piston-rod packing to pass up into the cylinder,



CYLINDER AND REPAIR PARTS

causing a shutdown. The accident occurred on Lake Huron in a heavy sea at 2 a.m., the time incidents of that nature usually happen.

A piece of sheet iron ⅛ in. thick, cut as shown at *C*, was forced into the bottom of the cylinder so that the clips extended out into the counterbore. Two holes were then drilled through the bottom head where it was secured by two bolts as shown. The engine was repacked and in operation again in about an hour. It was kept in operation in that condition for four days, and except for slight leakage around the piston rod the operation was perfect.

On reaching an Ohio port a false or counter stuffing-box was made, as shown at *B*, and a smaller-size packing used. Two seasons after that the engine was still in good condition and using the false stuffing-box.

J. H. CUNNINGHAM.

Toledo, Ohio.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Results of Burning Screenings

Mr. Mowat states in his article under this title in the May 7 issue that coke screenings can now be burned with success where previously it was futile to attempt it. I have successfully burned screenings for the past six years in New York City and vicinity. Mr. Mowat does not tell the type of grates used, the percentage of air space or the type of steam-jet blowers. I think the first of these items is important in successfully burning coke screenings.

His statement that "the pressure in the ashpit corresponding to a given steam pressure at the blowers was determined by the rate of firing" leads one to believe that the ashpit pressure was not taken during the test, but was computed from the rate of combustion and the steam pressure on the blowers. If this is so, the inadequate method would lead to inaccurate test results.

It is also said that every two or three minutes the fire was stirred on top and leveled off. This may be good in testing for maximum efficiency, but is extremely poor boiler-room practice because the economy effected by burning the coke breeze would be counteracted by the heavy expense incurred by having extra firemen.

I agree with him, however, as to the benefits of balanced draft, but how was the steam consumption of the blower computed? Was it during the actual test or on a previous test? I ask this because the percentage of steam used by steam blowers is sometimes exceptionally low. On a Stirling boiler rated at 287 hp., with coke breeze almost identical with that Mr. Mowat used, I obtained a rate of combustion of 25 lb. per square foot of grate area, with an ashpit pressure of 0.76 in. of water and a net equivalent evaporation from and at 212 deg. per pound of moist coke, of 6.6 compared to his 5.4, which is his best figure. He obtained an efficiency of 52 per cent. whereas mine is 62 per cent.

With this boiler the percentage of builders' rating developed was 141 per cent., which is almost identical with Mr. Mowat's result. The water was measured by using calibrated scales and weighing the water and fuel accurately.

ERNEST D. FIEUX.

New York City.

Erecting a Large Engine Flywheel

F. C. Holly's article under this heading in the Dec. 12 issue should prove of great value to most engineers. POWER should have more such articles. Articles on placing and aligning cylinders and bedplates of both horizontal and vertical engines would be welcome.

What size rope blocks would Mr. Holly use in turning half of a flywheel around the shaft, as mentioned in his article, the weight being about 5½ tons?

O. G. A. PETTERSON.

Manitoba, Canada.

Engineers All Dead

The foreword under this heading in the May 7 issue deserves the highest commendation. It makes an engineer feel proud after reading it. To know that the engineers of the "Carpathia" so willingly responded to their captain's call for "full speed ahead" when rushing to aid the "Titanic" is also gratifying.

J. H. POWELL.

Brooklyn, N. Y.

The Rateau Regenerator

An article in POWER, Apr. 23, reviewed the subject of steam regenerators. While it gives an interesting description of one of the types of my apparatus, it classifies the latter among the variations of this type which have been proposed since my invention. I feel obliged, therefore, to recall to you that my patents deal in general with the recuperation of exhaust steam by means of a receptacle inclosing masses capable of absorbing heat and interposed between the exhaust of engines running intermittently at high pressure and the admission of a machine running continuously at low pressure.

Let me add that my patents protect not only a definite type of apparatus, such as is represented by Fig. 1 of the article in question, but any accumulator of steam in which the water, whether by itself or conjointly with a metal, serves as the agent of accumulating the heat. What is more, I possess a patent, issued in 1901 which deals with an apparatus comprising superposed plates or equivalent bodies retaining the heat, between which the water falls from one plate or receptacle to the other.

The applications which I have made of the process invented by myself are extremely various and I therefore feel that the article you have published appears to unwarrantedly restrict the range of my invention.

A. RATEAU.

Paris, France.

Mr. Dickson's Pump Troubles

Mr. Dickson's letter in the Apr. 23 issue reminded me of a similar experience with a pulsometer pump. It defied the efforts of several to make it pump water and eventually I was asked to find the trouble. The piping was arranged as shown in Mr. Dickson's sketch. Examination showed the pulsometer to be all right, so the suction pipe was raised 6 in. As no further trouble occurred it is supposed that the end of the pipe was submerged in mud until lifted. This must have caused Mr. Dickson's trouble.

JAMES W. WILDE.

Pawtucket, R. I.

Where the Coil Should Be Placed

The illustration shows a simple and effective water-heating arrangement that may answer the requirements of Angelo Belmonte as stated in the Apr. 30 issue.

Provide a 30-gal. tank *A*, such as is used in connection with kitchen ranges, and support it at an elevation higher than the boiler. If the boiler is in a basement the tank may be hung from the beams of the floor above. Connect the city water or tank-supply pipe *B* almost to the bottom of the tank, as shown. Near this connect the pipe *C* to the bottom of the tank, running it down one side of the boiler setting.

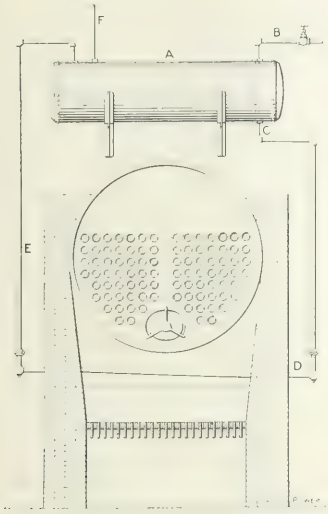
At a point where it will be exposed to the hot gases as at *D* introduce another pipe into the setting. This should run across the boiler and emerge at a point about an inch higher than where it enters. Tees connected to each end of this pipe and plugged afford a convenient means of cleaning out the mud and scale that accumulates.

The size of this pipe depends entirely upon the amount of water to be heated. If it is for a moderate-sized flat building, say four apartments, a 2-in. pipe will probably be satisfactory.

Where the pipe emerges from the boiler setting run another pipe *E* to the tank, connecting it so that the hot water

will enter at the top of the tank. Near this, also at the top, connect the service pipe *F*. A union on each side of the boiler where the pipes from the tank connect with the heating pipe provides an easy means of renewing the heater pipe should it become plugged with scale.

Avoid drops in the circulating pipe, as otherwise a pocket of steam will form,



Piping of Hot Water Tank

causing water-hammer; that is, there should be a continuous upward slope from the point where the pipe enters the boiler to where it enters the tank.

If it is more convenient, the heater pipe may have a return bend, emerging alongside of the point where it enters. In this case also the outlet should be higher than the inlet. This method is not as desirable as the heater pipe is harder to keep clean.

Ordinary steel or wrought-iron pipe should be used for the heating pipe as it transmits the heat more readily than the heavier weights. There is no danger of explosion; should steam form it will merely force the water back in the city main.

J. F. Mowat.

Joliet, Ill.

Mr. Belmonte's arrangement would be similar to an economizer for heating the feed water for boilers except that, in his case, the water would not need to be raised to so high a temperature. By locating a number of tubes connected at each end to headers or manifolds, in the flue leading from the boiler to the stack, the heat in the waste gases can be used. Mr. Belmonte does not give the temperature of these gases nor the amount of water to be heated, but, by proportioning the number of square feet of heating surface of the tubes to the temperature of the gases and the quantity of water to be heated he can readily get the results desired.

The best location for the arrangement must be determined by the space available as well as by the temperature of the gases. If the gases are extremely hot, the tubes should be placed near the stack; where the gases are cooler, there would be no advantage in subjecting them to very high temperatures.

The best material for both the tubes and the headers is undoubtedly cast iron. This is conclusively borne out in economizer construction. Gases of comparatively low temperatures have a much more deleterious effect on such tubes than those in the boiler itself, particularly if there is much sulphur in the coal.

Where cold water is used in an economizer or device of this kind, the tubes have a tendency to sweat, which also helps to form sulphuric acid. To prevent this, it is advisable to mix some of the hot water discharged with the cold entering water. This can be done by means of simple piping and is quite common in connection with economizers where feed-water heaters are not used.

The piping should be so arranged that the water will flow in the opposite direction to that of the gases. In this way the coldest gases will impinge on the tubes where the water is the coldest.

A relief valve should be attached to eliminate danger from explosion. There is always a danger that one of the tubes will clog, thus stopping the circulation and permitting the stationary water to get hot enough to burst the pipe.

In making an installation of this kind, however, the first thing to ascertain is that there is sufficient draft to take care of the gases with this added impediment to their flow.

Everard Brown.

Pittsburgh, Penn.

A pipe or coil should not be placed in any part of the combustion chamber of a return-tubular boiler for the purpose stated by Mr. Belmonte. Placing a pipe there makes absolutely necessary a constant circulation through the pipe and a constant stream of cold water leading to the coil; if it is connected, for instance, to a kitchen-range boiler, the water will probably get hot throughout, and, due to the intense heat in the combustion chamber, will heat the water quicker than it can travel through the pipe. The water in the coil or pipe will then separate, a steam pocket will be formed, the pipe overheat, and when the water rushes back it is almost certain to cause a break. Even if this did not happen, a burned-out pipe would probably result in a short time.

John Thorn.

London Junction, Ont.

Troublesome Condenser

The condenser layout described by Mr. Jacobs in the Mar. 12 issue is poor throughout and will not work without a few changes being made. As he obtains only a 22-in. vacuum and it is a 24-ft. drop to the lake, he cannot raise the water. As mercury is 13.6 times the weight of water,

$$\frac{22 \times 13.6}{12} = 24.93 \text{ ft.}$$

leaving only 0.93 ft. head to overcome the resistance of the four 4-in. ells and the 325 ft. of 4-in. pipe.

The best way to correct the evil is to put a motor-driven centrifugal pump on the suction line running to the lake. This will boost the water up to the condenser. If the discharge from the air pump has a drop of a few feet directly from the pump to the lake, no harm will be done if the vacuum breaks.

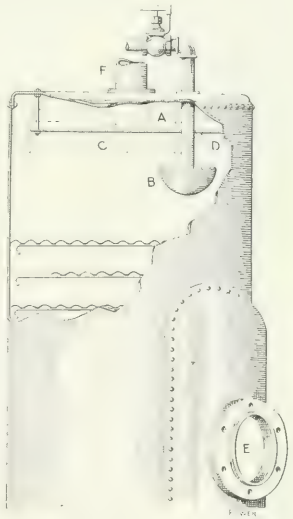
C. V. Bennett.

Chicago, Ill.

Noisy Heater

As is suggested in recent letters answering my inquiry under this heading in the Feb. 6 issue, I submit illustrations to give a clearer idea of the heater.

Mr. Hoppe's suggestion in the Mar. 26 issue is not feasible, as a study of the sketch will confirm. Mr. Meinzers' suggestion, in the same issue, was car-



Showing Supply Piping to Water Heater

ried out by heating the water before it entered the steam space and by partially sealing the cold-water supply pipe, but the heater made more noise than before.

The dotted lines *A* show the first change made in the cold-water supply pipe, thus eliminating the overflow box *B*. The dotted lines *C* show a further change made in

this pipe in an attempt to temper the water before it mingled with the exhaust steam. I put in the round plate *D* through which the water percolates in fine streams, enabling it to be heated more quickly. The exhaust-steam inlet is shown at *E* and the outlet at *F*. I admitted hot water to the cold-water supply before it entered the heater. This reduced the noise on light loads, but on the heavy night loads, when more water was evaporated, the noise increased.

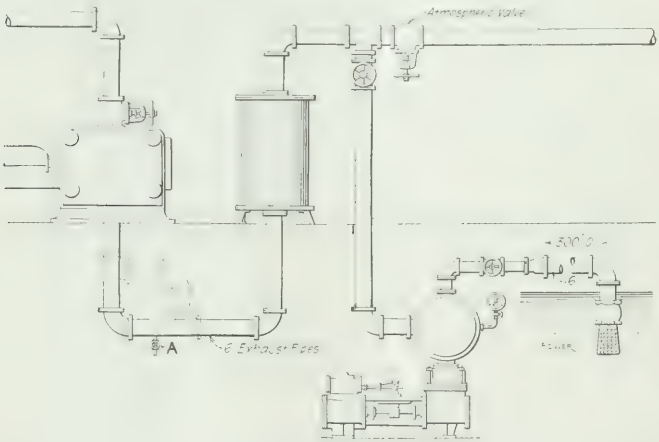
I now feel sure that the steam in the heater condenses, creating a vacuum which breaks and causes the noise; it is not due to water-hammer. However, while I am experimenting, will others interested offer suggestions?

L. C. GREENE.

Gallipolis, Ohio.

Mr. Jacobs' Condenser

B. A. Jacobs' condenser, mentioned in the Apr. 30 issue, will never work satisfactorily until the lift is shortened on the water-suction line. The pump is working against a static head of 24 ft. plus the friction of four ells and 300 ft. of pipe. Manufacturers do not guarantee jet condensers and air pumps to work satisfactorily with more than 20-ft. lift and 5-ft. discharge head.



PROPOSED CHANGE IN MR. DICKSON'S CONDENSER LAYOUT

If the condenser was arranged as illustrated, the lift would be shortened at least 6 ft. and the friction of two ells saved; all the pipe line must be absolutely tight.

I suggest changing the exhaust line as shown, thus saving two ells; also put in a 1-in. drain, *A*, to avoid water-hammer when the engine is started after several hours' shutdown. If the condenser loses its vacuum while the engine is running, there being no automatic atmospheric valve, the results will depend upon the load on the engine. If it is doing its rated horsepower or is slightly overloaded when the vacuum is lost the engine will slow down and probably stop before enough back pressure is accumulated to wreck the condenser.

If the engine is working light and the vacuum is lost, the governor will lengthen the cutoff and admit more steam to the condenser until the back pressure ruptures it or stops the engine.

C. E. ALDRICH.

Tranquility, Calif.

Balanced Draft Systems

The balanced-draft systems described in POWER recently were of much interest to me and perhaps others may be interested in the arrangement in our plant.

We operate water-tube boilers of 350 hp. each, which furnish steam to three 1000-kw. units. The forced draft is obtained from a fan and is automatically regulated; natural draft is regulated with individual dampers for each boiler by a rod extending from the front to the rear, where the damper-chain is wound around it to suit the position of the damper, thus making it possible for the firemen to adjust the dampers to any desired position.

For 16 of the 24 hours of daily operation the load is nearly uniform and the fan runs at uniform speed which enables the firemen to obtain a balanced draft.

During these hours the gas samples taken average from 9 to 14 per cent. of CO_2. The other eight hours the load is variable; therefore we cannot obtain balanced draft at all times, which lowers the percentage of CO_2 considerably.

Another advantage of balanced draft is that it keeps the fires more level. I have found that with an excess of draft above the grates the air will flow through the fuel bed very rapidly, and will not come in contact with the fuel, but when it goes through, the oxygen in excess of that which unites with the carbon and hydrogen escapes up the chimney. With balanced draft the air does not go through so rapidly and more oxygen will unite with the carbon after it has entered above the fuel bed. We also fire alternately and only one furnace door is opened at a time, which greatly aids in reducing the CO.

A. NORRMAN.

Pottsville, Penn.

The Arithmetical Mean

Mr. Richardson makes a good point in the May 7 issue relative to my article on the arithmetical mean when he calls attention to the fact that the first and last of a series of observations upon a variable quantity should be averaged with only half the weight of the others. When the measuring apparatus is so elaborate as to be recording, however, it is likely that an averaging instrument will be applicable and available. When such is the case, the rule given is not needed for the mean height of either rectangular or polar charts.

Mr. Richardson implies that the question, in the case of the venturi meter, whether to take the average of the square roots of the readings or the square root of their average is purely an academic one. There is a large class of engineering measurements, depending upon the relation that the desired quantity equals a constant multiplied by the square root of a measured head. The instrument is not always graduated in terms of the desired quantity, but in inches or feet of head, as, for instance, hook gages for weir measurements, pitot tubes for air or gas lines, manometers used on standard orifices, etc. When this is the case, a calibrating curve is used by which the desired quantity can be obtained at once from the instrument reading without calculation. It is to such cases that my illustration of the venturi meter applies.

JULIAN C. SMALLWOOD.

Syracuse, N. Y.

Testing Engines with a Prony Brake

My experience with water-cooled prony brakes is similar to that of Allen Slade, as told in the Apr. 16 issue. To overcome my trouble I put two pieces of ordinary white soap between the brake bands so that they would rub on the wheel; then the supply of water was cut down until a little steam was formed, and the brake worked perfectly. This method was used on a pulley 12 in. in diameter with a 12-in. face and took care of 10 hp. at 750 r.p.m.

Oil is all right up to the point where excessive heating occurs, but water and soap will work more satisfactorily under such conditions.

A. T. KASLEY.

Swissvale, Penn.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

Diaphragm Pump

What is a diaphragm pump, and how does it operate?

J. J. F.

A diaphragm pump is one in which the displacing action is obtained by reciprocating a circular or other shaped diaphragm of rubber, leather or other flexible material, fastened and sealed at its edges to the pump body. The space underneath the diaphragm forms the suction chamber. When designed for raising liquids, this pump is usually so arranged that the diaphragm will be horizontal, with a delivery check valve in the center of the diaphragm. In operation, the diaphragm is reciprocated by short strokes in and out of the suction chamber by a pump rod attached to the central portion of the diaphragm. The principle of the pump is similar to that of a bellows.

Indicating a Pump

How is a pump indicated which has no outside parts suitable for the attachment of a reducing motion?

S. C.

The indicator cock connections to the cylinders are made in the same manner as in indicating an engine. Attachment for the indicator motion is obtained by extending the piston rod, like a tail-rod, through a stuffing-box set in the head of the steam or water cylinder. Such a tail-rod need not be over about one-quarter the diameter of the main piston rod and is readily attached by drilling and tapping a hole in the end of the piston rod for receiving the screwed end of the tail-rod.

Sweating of Iron Water Tank

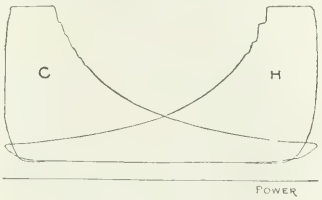
What preparation can be applied to a steel water tank to prevent sweating?

J. O. W.

So called "sweating" is not water which oozes through from the inside of the tank, but is moisture deposited by condensation from the air due to reducing its temperature by contact with the tank to a point where it contains more moisture than it can hold in suspension. The remedy is to cover the sides and bottom of the tank with a nonconducting covering which will present a surface to the air that is nearly the latter's temperature. The covering should be applied when the tank has been empty long enough to have attained the same temperature as the air; otherwise some moisture will be inclosed and soon saturate the covering, nullifying its noncondensing properties. For the same reason the covering should be protected from rain.

Sticking of Indicator Piston

These diagrams were taken with a new indicator from a 22x22-in. ice-plant Corliss engine making 56 r.p.m. What causes



STICKING OF INDICATOR PISTON

the notches in the expansion lines of the diagrams?

V. K. S.

The very sharp cutoff and the square corners of the notches in the expansion lines are undoubtedly due to the sticking of the indicator piston in its cylinder. This imperfect action is likely to occur from lack of lubrication, or from neglecting to thoroughly blow out all pipe scale and loose dirt from pipe connections before applying an indicator.

Unequal Pipe Expansion

In a steam-heating system, will the expansion of two parallel straight lines of iron or steel piping, run as a main and its drip main, each 150 ft. long, be the same for corresponding points along their length; that is, will the difference of expansion be so little, that the two pipes may be connected together at intervals by tees and close nipples? What would be the cause of difference of expansion? What should be the controlling considerations in proportioning the largest size of low-pressure steam-heating main that can be supplied through a pressure-reducing and regulating valve connected to a stated size of high-pressure supply pipe?

G. W. R.

For a variety of reasons the two pipes will not expand alike, nor will they contract to their original fitted-up lengths after being once heated. The evidence of unequal expansion and contraction of pipes is to be observed in the distortion which takes place in the pipes of a wall coil made up only of straight runs of pipe connected together by headers, without any mitre or spring ends. The connecting together of two such pipes results in warping and buckling the first time steam is turned on, and if connected together by close fittings would probably result in rupture of the latter.

The leading causes for difference in expansion are actual difference in texture of the material of the two pipes and actual difference of temperature.

Difference in texture of material may result from variations in raw material, method of manufacture and chance differences in mechanical treatment which a pipe may receive from the time it is first formed down to the last finishing touches of the steam fitter, and it is practically impossible to warm up two such pipes to absolutely the same temperature or to expose them to absolutely the same cooling effect from the surrounding atmosphere.

Reducing regulating valves are supposed to be ample for delivering all steam that can flow through high-pressure pipes, corresponding to the sizes of their inlets within the ranges of pressures for which they are supposed to be used. To deliver any given amount of steam from ordinary high pressures, reduced to the ordinary low pressures used in steam heating, it is a good rule to have the low-pressure pipe eight times the diameter of the high-pressure connection.

This ratio assumes that the pressure regulator is capable of delivering the full capacity of the pipe size of the high-pressure connection

Lap of Belts

What is the proper length of lap for single and double belts, 4 to 18 in. wide?

P. E. M.

Most manufacturers make the scarf length equal the belt width for all single and double belts, down to 5 in. wide; and for belts of less than that width make the scarf about 1 in. longer than the belt width. Double belts over 10 in. wide should have the scarf ends each covered with a tuck or dovetail, formed by a narrow overlap of the corresponding thickness of the opposite end of the belt

Study Questions

This Week's Questions
Last Week's Answers

26. A locomotive is stopped with the piston on one side at the head end of its stroke. It is found that the distance from the center of the crosshead to the center of the driven axle on this side is 7½ ft., while on the other side it is 6 ft. 1½ in. What are the crank and connecting-rod lengths, center to center?

27. Given the same conditions as in question No. 22 (answer to which is printed below) except that the tank is to be open, i.e., without a top, what then should be its dimensions?

28. Convert 5, 14, 41, 68, 158 and 266 deg. Fahrenheit to Centigrade; and 1, —30, —25, 90 and 120 deg. Centigrade to Fahrenheit.

29. If a cubic foot of wrought iron weighs 480 lb., what is the weight of a flat bar 2 in. wide, ½ in. thick and 1 yd. long?

30. What horsepower will be required to pump 108,000 gal. of water per hour from a coal mine 250 ft. deep, neglecting friction in the pipes, etc.?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

21. It would take 2 hr. to go up a hill 30 miles long and 1 hr. to return, or 3 hr. in all for the 60 miles. On the level the same distance is covered in the same time, 60 miles in 3 hr. Therefore, whatever the contour of the course, the round trip will be made in the same time as though the course were entirely flat. It will therefore take 5 hr. to go 50 miles and return.

22. Taking the weight of a cubic foot of water as 62.5 lb., the volume of 500 lb. is 8 cu.ft. A sphere has the least surface for a given volume (shown by soap bubbles and toy balloons); and among rectangular objects, a cube is the nearest like a sphere; therefore the tank should be cubical. A cube containing 8 cu.ft. will measure on each edge

$$\sqrt[3]{8} = 2 \text{ ft}$$

The inside of the tank then will measure 2 × 2 × 2 ft. and its surface 6 (2 × 2) = 24 sq.ft.

23. As the strength and weight will both increase with increase of area of cross-section and in the same proportion, the size of the wire is not necessary to the calculation. For convenience take the cross-sectional area as 1 sq.in.; then the tensile strength is 40,000 lb. and the weight of a length of 1728 in. is 555 lb. The length of the wire in feet that will break with its own weight is

$$40{,}000 \div \frac{555}{1728} \times 12 = 10{,}378.38 \text{ ft.}$$

24. Between freezing and boiling on the Fahrenheit scale is

$$212 - 32 = 180 \text{ deg.}$$

and on the Centigrade scale

$$100 - 0 = 100 \text{ deg.}$$

A Fahrenheit degree therefore is ⁵/₉ of a Centigrade degree and a rise of 45 deg. on a Fahrenheit thermometer corresponds to a rise of

$$45 \times {}^5/_9 = 25 \text{ deg.}$$

on a Centigrade thermometer.

25. A displacement of 1.25 gal. per revolution equals

$$1.25 \times 8.3356 = 10.4195 \text{ lb. per revolution}$$

Corrected for slip,

$$10.4195 \times 0.80 = 8.3356 \text{ lb.}$$

A boiler horsepower of 30 lb. an hour is 0.5 lb. a minute

$$\frac{8.3356}{0.5} = 16.6712 = \text{boiler horsepower per revolution per minute}$$

DuBois N. A. S. E. Convention

On June 7 and 8 the Pennsylvania State Association, N. A. S. E., held its thirteenth annual convention at DuBois, Penn. It was well attended by both delegates and members of the American Supply Men's Association.

The convention opened on Friday morning with the usual formalities at Eagles' Hall. Addresses of welcome were made by A. L. Cole and F. S. Weber, for the city of DuBois, National President E. H. Kearney and State Deputy John M. Lynch responding. During the business session, State President Bumiller delivered an address on education and legislative uplift.

In the afternoon the members, escorted by Superintendent of Motive Power Harrison, visited the B., R. & P. locomotive shops.

Later the party was taken to the DuBois Brewing Co.'s big plant, where a luncheon was served to its visitors.

At the Saturday morning session the following officers were elected and installed by President Kearney: State president, N. D. Orms, of Johnstown; vice-president, A. C. Cotton, Pittsburgh; secretary, Albert Munsinger, Williamsport; treasurer, D E. Seeley, DuBois; conductor, W. C. Smyor, Sharon; doorkeeper, J. D. Rostum, Chester.

Sixty delegates and supplymen attended the banquet at the Forte Worth Hotel in the evening, at which Samuel B. Force acted as toastmaster. Among the speakers were National President Kearney, President Bumiller, State Treasurer Seeley, and Messrs. Green, Johnston, Walbieser, Lynch, Cole and Weber.

The Exhibits

The supplymen's exhibits were attractively displayed at Eagles' Hall and were inspected by a large number. The following firms exhibited: Clement Reste:n Co., Philadelphia; the Fairbanks Co., Pittsburgh; the Atlantic Refining Co., DuBois; Alberger Pump Co., Alberger Condenser Co., Pittsburgh; Jenkins Bros., Philadelphia; H. W. Johns-Manville Co., New York; V. D. Anderson Co., Cleveland; Quaker City Rubber Co., Philadelphia; Home Rubber Co., Trenton, N. J.; Dearborn Drug & Chemical Works, Pittsburgh; the Lagonda Manufacturing Co., Pittsburgh; POWER, New York; Bird-Archer Co., New York; Garlock Packing Co., Palmyra, N. Y.; the Lunkenheimer Co., Cincinnati; Greene, Tweed & Co., New York; International Correspondence Schools, Scranton, Penn.; the Vulcan Soot Cleaner Co., DuBois; *National Engineer*, Chicago; Osborne Machine Co., DuBois; Anchor Packing Co., Pittsburgh; Crandall Packing Co., Palmyra, N. Y.; Eagle Lubricator Co., Pittsburgh; Epping-Carpenter Co., Pittsburgh; Homestead Valve Co., Homestead; Ridgway Dynamo & Engine Co., Ridgway; the Peerless Rubber Co., New York; the Westinghouse Manufacturing Co., Pittsburgh; the Liberty Manufacturing Co., Pittsburgh.

Indiana State N. A. S. E. Convention

The eighth annual, and probably the most successful, convention of the Indiana state organization of the National Association of Stationary Engineers passed into history Saturday evening, June 8, after three days' session at Evansville.

The meeting opened at 10 a.m., June 6. Emil Heeger, chairman of the state association, after a brief address, introduced City Attorney George A. Cunningham, who represented Mayor Charles Heilman. Mr. Cunningham emphasized the important work of the engineer and the debt which humanity owes him, lauding the purpose of the association and expressing the hope that it would attain the success it so richly deserves.

National Vice-president John McGrath in his response briefly outlined the purposes and principles of the association, thorough education, sane license laws and civil-service examinations or their equivalent in the selection of engineers for the public employment.

F. E. Ramsley, president of the Central State Exhibitors Association, explained the object of conducting an exhibit at a convention. The displays are made to familiarize engineers with the various materials and devices on the market; and immediate returns are not expected. An adjournment was then taken until 1:30 p.m., when a short closed meeting was held at which the officers' reports were

read and acted upon. A discussion upon ways and means of propagating the association brought out many valuable suggestions.

At the evening session, National Secretary Fred Raven spoke of the splendid work and coöperation of the supplymen in making the convention a success. He urged all interested in the association to do their best missionary work and bring in as many new members as possible that the organization might continue to prosper and be an institution of benefit to all.

R. V. Stuerve, of the Allis-Chalmers Co., gave a lecture on "Steam Turbines," illustrated with many stereopticon slides showing the principles of design, the construction of the various parts and numerous typical installations. He first briefly enumerated the several characteristics of the two pure types of turbine, impulse and reaction, and then took up their construction step by step and pointed out the interesting features of operation.

At the Friday morning session, Vice-president John McGrath gave a long welfare talk. Fred Raven, speaking on organization, gave as one sure way to make any organization robust and healthy to elect competent officials. He reminded his hearers that the state and subordinate associations may obtain advice and personal and financial aid from the national body if they will plainly state their wants.

In the afternoon the delegates and guests visited the Evansville Manual Training School and the plants of the Cook Brewing Co. and the Evansville Brewing Association. Later many visited the Fair Grounds where an aviation circus was in progress.

At the evening meeting, Theodore Wineshank, a heating engineer and contractor of Indianapolis, gave a lecture on "Vacuum Heating," illustrated with slides. Having shown that the latent heat of steam produces the main part of the heating effect, and hence low-pressure steam is practically as effective as high-pressure, he described the essential features of various types of installation. The various devices employed were also explained, such as thermostatic valves, "modulation" valves, which in one turn of the handle swing from the closed position to the wide-open; vacuum-controlling valves, etc. He also displayed views of various types of radiators, ventilating fans and air washers.

A smoker and buffet luncheon, given by the entertainment committee, followed. The program was largely impromptu, Toastmaster Raven unexpectedly calling on each to contribute his share.

At the closed session Saturday morning, Terre Haute was chosen as the next meeting place and the following officers were elected: Charles Streithof, Evansville, president; George R. Fields, Terre Haute, vice-president; Louis Minke, Evansville, secretary; Albert Franke, Terre Haute, treasurer, and Emil Heeger, Evansville, state deputy.

Some of Those Who Attended the Meeting of the Indiana State N. A. S. E. at Evansville

In the afternoon an automobile ride was taken through the city and dinner was served at Cook's Park. Following the dinner, Secretary Raven installed the new officers and presented the past president's jewel to H. E. Smith.

The exhibit hall was well arranged and the following members and associates of the Central States Exhibitors Association had effective exhibits: American Steam Gauge & Valve Manufacturing Co., V. D. Anderson Co., Crandall Packing Co., Dearborn Drug & Chemical Works, Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Hills, McCanna Co., Home Rubber Co., Jenkins Bros., H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., Osborne Valve & Joint Co., William Powell Co., Power, Schaefer & Budenberg Co., C. E. Squires Co., United States Graphite Co., Cling-Surface Co., Diamond Power Specialty Co., Kollker Electric Co., H. Mueller Manufacturing Co., *National Engineer*, A. L. Swanson & Co.

A. O. S. E. Convention

The twenty-sixth annual convention of the Supreme Council of the American Order of Steam Engineers was held at Allentown, Penn., during the week commencing June 3. The Allen House was the headquarters. Twenty-three councils of the order were represented by 105 delegates, and there were also present many past presidents and prominent members of the organization.

The Supply Men's Association, connected with the order, held its mechanical exhibition in the main hall under the grandstand at the fair grounds of the Lehigh Agricultural Society. The display was tastefully arranged and interesting to the delegates and visitors. The several business sessions of the convention were held in an adjoining hall.

The exhibit was formally opened on Monday evening with a short address by Past President Richard Foley. He then introduced Attorney Fred B. Gernerd, who spoke interestingly of Allentown.

On Monday morning, Mayor Charles W. Rinn welcomed the convention to the city. Supreme President Louis G. Schlehner's report shows progress in every department, and the secretary's report shows the association to be in a prosperous financial condition.

It is expected that the coming year will be a healthy one in the increase of members. Heretofore operating engineers only were admitted, but now that the supreme body has let down the bars other than operating and licensed engineers are eligible to membership.

The entertainment features included automobile rides for the ladies, a trip by

trolley to Central Park, an enjoyable vaudeville entertainment in the exhibit hall, and a concert by the Bethlehem Steel Co. Band, also in the exhibit hall.

The delegates elected the following supreme officers: D. B. Heilman, chief engineer; George W. Goodwin, first assistant engineer; E. Harding, recording engineer; F. J. Armbuster, corresponding engineer; Michael Helmstridt, treasurer; Thomas Montgomery, senior master mechanic; Thomas Marshall, Jr., master mechanic; W. H. Baer, chaplain; W. J. Courtney, inside sentinel; Philip Kirkwood, outside sentinel; Louis G. Schlehner, William Parient and W. S. Smith, trustees.

At the final meeting of the Supply Men's Association the officers elected for the ensuing year were: Frank Martin, president; Frederick L. Jahn, vice-president; Charles Wilhoft, secretary; John W. Armour, treasurer; Hart Hill, director of exhibits. Handsome tokens of appreciation were presented to the retiring president and director of exhibits, and also to the treasurer.

The following firms occupied booths at the convention: John R. Livezey; Lyons, Borgner Co.; Bird-Archer Co.; Frill Indicator Co.; Greene, Tweed & Co.; Keystone Lubricating Co.; Rooksby & Co.; New York Belting Co., Ltd.; Engineering Supply Co.; George W. Lord Co.; William C. Robinson Son & Co.; H. B. Underwood Co.; Philadelphia Bourse Co.; Hawk-Eye Compound Co.; Crandall Packing Co.; the Roto Co.; R. & J. Dick, Ltd.; France Packing Co.; Lagonda Manufacturing Co.; *Popular Engineer;* Anchor Packing Co.; Strong, Carlisle & Hammond Co.; Liberty Manufacturing Co.; *Practical Engineer;* Warren Webster Co.; Home Rubber Co.; Jenkins Bros.; Dearborn Drug & Chemical Works; POWER; Albright Son & Co.; New York & New Jersey Lubricating Co.; the Fairbanks Co.; Westinghouse Air Brake Co.; National Tube Co.; McLeod & Henry Co.; Diamond Power Specialty Co.; McArdle & Cooney; Watson & McDaniel Co.; Lewis-Rott Co.; the Lunkenheimer Co.; Garlock Packing Co.; *Southern Engineer;* Macon, Jr. Co.; Buhne Metal Co.; Ashton Valve Co.

It was decided to hold the 1913 convention at Philadelphia, Penn.

Baltimore Engineers Club

The Engineers' Club, of Baltimore, held an important meeting Thursday evening, June 6, the last before the fall. The officers elected for the ensuing year are R. Keith Compton, president; George W. Wright, vice-president; W. W. Pagon, secretary, and J. Fletcher Apsey, treasurer. The new directors are W. W. Crosby, Emory Sudler and B. C. Howard. Holdover directors until 1913, Oscar F. Lackey, John K. Flick and Swepson Earle.

The matter of changing the club name to the Engineers' Society of Baltimore, or the Engineers' Society of Maryland, will be decided definitely at the first fall meeting.

In the discussion relative to securing the 1913 convention of the American Society of Civil Engineers for Baltimore, Mr. Earle asked the members to exert all possible efforts to get it and William D. Janney was designated to go to New York and have a conference with Charles Warren Hunt, secretary of the American Society, to that end.

OBITUARY

THEODORE ALBERT

On May 27, Theodore Albert, president of the William Powell Co., Cincinnati, Ohio, died at his home in that city.

THEODORE ALBERT

Mr. Albert's career is a notable example of the boy who from a humble beginning makes the best of his opportunities and by perseverance and hard work wins his way to the top. Nearly 40 years ago, at the age of 18, he commenced his business life in the employ of the Powell company as an office boy. The company at that time was modest in size and capacity. Step by step, Mr. Albert was given added responsibility, first as bookkeeper, then assistant manager, manager, and finally upon the death of James Powell, in February, 1908, he succeeded him as president.

Among his fellow officers, some of whom knew him intimately for over 20 years, he was known as a man of modesty, indefatigable energy and industry and his friends held him in the highest honor and trust.

Mr. Albert never married but devoted his home life to his mother, whom he survived by only about a year. Between them existed a very deep affection and their life together was a beautiful example of mother and son comradeship.

Milwaukee Smoke Inspector's Report

By a state smoke-abatement law recently passed, the Wisconsin legislature gives a city smoke inspector jurisdiction over all territory one mile from the city limits. This law, says Charles Poethke, smoke inspector of Milwaukee, in his yearly report now does justice to manufacturers just within the city limits where formerly a far worse offender outside the line could not be reached.

While the law was strongly opposed by the railroads, the protests of a large committee of citizens convinced the legislature of its necessity. One of the offending railroads has already equipped its power plant with automatic smokeless furnaces.

Two deputy inspectors have been appointed to Milwaukee's department and greatly increase its efficiency. Where it formerly required two men to prove a violation of the ordinance, one as a complainant and the other as a witness, a deputy can now get a conviction with the assistance of a camera. Every violation is photographed by the inspectors and the time the photograph was taken is marked on the smoke chart together with the length of time the violation continued. The court has in all cases sustained the work of the department, imposing fines on all offenders where the evidence warranted a prosecution.

Many firms, states Mr. Poethke, seem to think that the installation of a certain smokeless furnace or stoker is all that is necessary and are surprised when a violation is charged against their plant. This is due to men operating these furnaces contrary to instructions or being incompetent, or negligent in their duties. No fireman should be permitted to run any mechanical stoker without being fully acquainted with its operation. Many good stokers and smokeless furnaces have been condemned just for this reason. Every stoker manufacturer will guarantee his device to do the work and no payment to be made until satisfactory and approved by the smoke department. Smaller plants as a rule resort to Pocahontas coal where the boiler setting or other circumstances will not permit installing mechanical or other furnaces. Hard-coal dust is also used to some extent, but as the market is limited and it cannot be had at all times it is not in great favor, especially when draft conditions are poor.

An ordinance, at present pending before the Milwaukee Common Council, prohibits using soft coal on railroads, tugs and steamboats within the limits of the city and one mile therefrom.

POWER

Vol. 35 NEW YORK, JUNE 25, 1912 No. 26

One as Useful as the Other

Looks like this turbine is running itself while Billy Sleeper is in the Dreamland Pool Parlor. A cigar sign could just as well take his place.

Because a turbine calls for less physical effort to keep it going than a reciprocating engine is no reason why the engineer should sleep on the job.

About the only rosy dreams that come true in a power plant are hoped-for reward and advancement in consequence of strict and constant attention to duty.

The wooden Indian is fast disappearing from in front of the tobacco tepees and the somnolent engineer disappears even faster when the plant owner gets wise to his habits.

Power Plant of Sears, Roebuck & Co.

By C. A. Tupper

A showy Corliss-engine noncondensing plant in which the exhaust steam is used for heating.

Coal handling facilities and equipment for fire protection are unusually complete.

Sears, Roebuck & Co., the mail-order house, occupying a large group of buildings on the outskirts of Chicago, have one of the most modern and complete power plants in that city, under the direction of A. F. Wright, chief engineer. The electric generating plant, centrally located, covers 30,000 sq.ft. It is entirely fireproof, being constructed of steel, concrete and brick, and was specially designed to accommodate the machinery installed. The engines, boilers, generators, etc., are on the ground floor, while the auxiliary apparatus, piping, etc., are in the basement. Longitudinally the building is divided into boiler and engine rooms by a wall extending its full height. A 15-ton crane travels the length of the engine room.

Coal is received on a spur along the south side of the power house, equipped with a 100-ton standard Fairbanks-Morse track scale. That for immediate use in the power plant is dumped into a reinforced-concrete hopper over the crushing rolls, and after leaving these is transported by a steel belt conveyor to a bucket conveyor serving the bunkers. At the south side of the power house are concrete storage bins of 2200 tons capacity. In these the coal can be submerged in water and kept indefinitely. Each bin can be drained to the sewer when coal is to be removed. The coal is handled to and from these bins by an electric crane with a 3-yd. clamshell bucket.

At the bunker loft the coal from the bucket elevator is taken by a portable dumper and distributed to bins, each holding 100 long tons. From these, spouts lead to the stokers, which have moving chain grates driven by an 8x8-in. Wachs engine. Two furnaces burn refuse from the company's various departments. This refuse is chuted to the basement of each building and taken by trucks, through tunnels, to two Williams pulverizers. After being ground it is blown through ducts by a fan to a cyclone on the boiler-house roof and falls by gravity to the furnaces. The same bucket conveyor that handles the coal takes the ashes to a 50-ton bunker, from the bottom of which they are drawn off to a steel belt conveyor discharging to railroad cars outside.

Eight Aultman & Taylor water-tube boilers, with superheaters, are arranged in batteries of two each in a single row. The aggregate normal rating is 4000 hp. One man operates this part of the plant. Draft is furnished by a 225x14-ft. brick stack, on a concrete foundation 60 ft. deep. Feed water from the city mains and returns from the heating system discharge into an open heater, from which it is delivered to the boilers by two Fairbanks-Morse 10x16x8.5x18-in. compound duplex pumps equipped with Fisher governors.

Steam at 150 lb. pressure and 70 deg. F. superheat passes through 6-in. bends to a 16-in. loop header to supply any engine from either side of the boiler plant.

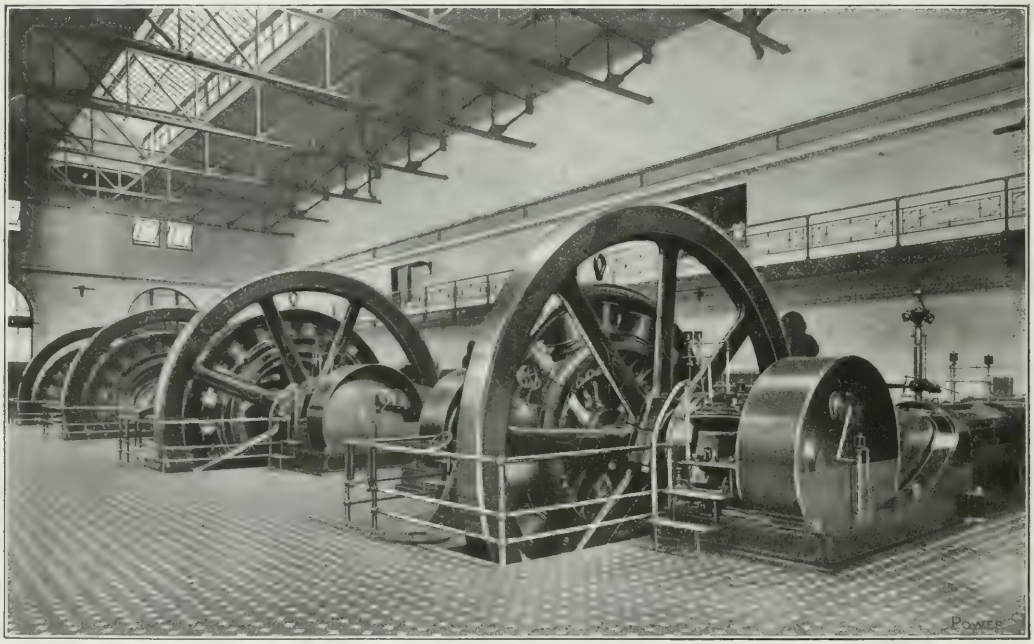


FIG. 1. ENGINE ROOM OF SEARS-ROEBUCK POWER PLANT

In the engine room are four generating sets. Three are 24 and 50 by 48-in. horizontal cross-compound Corliss engines making 85 r.p.m., directly connected to 750-kw. continuous-current generators. The fourth is a 20 and 40 by 42-in. engine driving a 500-kw. generator at 90 r.p.m. These units were built by the Allis-Chalmers Co. Each engine has a Richardson-Phoenix sight-feed oil pump. All of the lubricating oil is supplied from an

elevated tank, to which it is pumped back after filtering.

Light loads at night and on Sundays are carried by two Allis-Chalmers 220-volt generators driven by Ames engines, one of 50 kw. by a 12x12-in. engine and one of 100 kw. by a 14x14-in. engine. All six generators are compound wound.

The engines run noncondensing. Their exhaust passes to a 36-in. collector, with two Austin oil separators and thence to an expansion chamber where live steam can be added. It then goes into the heating system, or to the atmosphere.

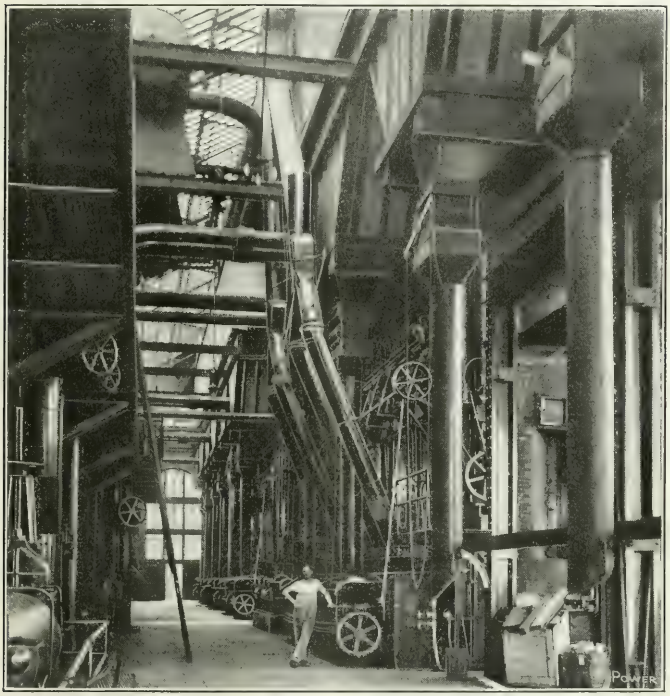


FIG. 2. BOILER PLANT HAVING NORMAL RATING OF 4000 HP.

The current mains lead through conduits under the floor to a 20-panel switchboard at one side of the room, which is of standard angle-iron frame construction, with white Tennessee marble front. Each panel has the usual controlling, regulating and current-indicating apparatus, including integrating and recording instruments. The busbar system is in duplicate, each part interchangeable with the other.

Current is distributed through cables laid in tunnels (which also contain the pipes carrying water, steam for heating, etc.) to the different buildings. In these, including the power plant itself, and on conveyors, elevators, etc., outside, are nearly 500 motors in sizes from ½ to 150 hp. They are used for a great variety of purposes, including the operation of a printing plant. The lighting system is also very extensive, including 44 inclosed-arc, 19,700 incandescent, 4200 Nernst, 12 Cooper Hewitt and 1913 tungsten lamps. The latter are used mostly with the indirect system of lighting in the administration building.

While radiators are installed, particularly in the more exposed parts, most of the heating is by a hot-blast system, which also ventilates and in summer circulates cold air. There are 33 motor-driven fans. The air supply is taken through filter chambers. Two 16 and 22 by 20-in. Marsh vacuum pumps in the sub-basement are on the heating system, discharging into an open tank on the basement floor; from here the return water is delivered to the heater in the boiler room by two 8 and 12 by 12-in. Marsh steam pumps.

In the engine-room basement is a 30-ton Carbondale live-steam refrigerating machine, used to make ice for the restaurants, water coolers, etc., and also a motor-driven triplex house pump. The filtered drinking water is handled by two 10 and 7½ by 12-in. duplex steam pumps.

Three two-stage Laidlaw-Dunn-Gordon air compressors in the engine room, one of 300, one of 400 and one of 1000 cu.ft. per minute capacity at 100 lb. pressure, the latter a cross-compound Corliss, supply air for cleaning, pneumatic hoists and pumping water from two deep wells.

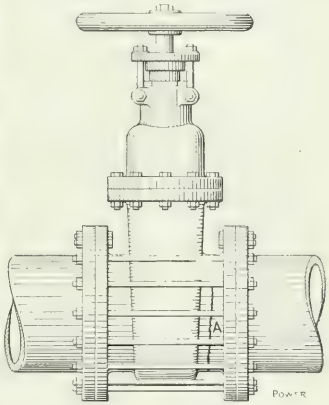
The pneumatic-tube system is operated by three Connersville blowers, each of 118 cu.ft. per revolution capacity, independently belted to 100-hp. motors. There are nine miles of 4-in. tubing in this system.

In the engine room are two 8x12x8x18-in. compound duplex steam house pumps, one 18x22½x22½x5⅛x24-in. compound Corliss, one 20x31x9x24-in. and one 14x20x5¼x18-in. compound duplex elevator pumps, and three 18x10x12-in. duplex fire pumps, each having a capacity of 1000 gal. per minute. The fire pumps are controlled by Foster piston-actuated governors, and are in constant operation, maintaining 125 lb. pressure.

The fire-protection equipment is very complete and under the control of a supervisory signal system which automatically indicates the condition of the apparatus at each point. Any alarms turned in are registered in the fire marshal's office, in which is installed a very elaborate switchboard for this purpose. This system and the automatic telephone system and signal bells are operated with 20-volt current furnished by two motor-generators in the engine room.

Gate Valve Repair

A large gate valve in the suction pipe of a 3,000,000-gallon pumping engine cracked, as shown by the line *A* in the accompanying illustration.



GATE VALVE AS REPAIRED

Removing such a valve was not only a laborious job, but an expensive one as well. There were sixteen ¾-inch bolts holding the flanges of the valve and pipe together. Seven of these bolts were removed and through bolts substituted, passing through both flanges of the valve and the two pipe flanges, as indicated. When the bolt nuts were tightened the metal on both sides of the crack was drawn together and the leak gave no further trouble.

This fracture was caused by shutting down the pump too quickly which created an excessive pressure in the suction pipe.

Tom Hunter, Hoisting Engineer

By Warren O. Rogers

Hunter explains the use and operation of the Vulcan Corliss hoisting engine for mine work, and tells how the governor is cut out of control.

He also tells why hoisting engines are not operated condensing and then suggests how a condenser could be used.

The next day, after viewing the operation of the safety stop for hoisting engines, I passed one of the manufacturing plants of the town and the "click, click" of the engine attracted my attention as the sound escaped through a partly open window of the engine room.

Being curious to see what type of engine this might be, I entered the engine room and found a Corliss making about 95 r.p.m.; the rim speed on the flywheel was close to a mile a minute. After a pleasant visit with the engineer I went on my way, but I could not help wondering why I had not seen a Corliss hoisting engine at the numerous mines I had visited.

Corliss Hoisting Engine

If a Corliss engine is economical in one plant, I reasoned, it should be a money saver in another. The next morning after breakfast I met Hunter and asked him how it was that we had seen no Corliss hoisting engine, and if there were none in use.

"Why, there are Corliss hoisting engines—quite a few of them. There are several of them in nearby towns. Suppose we take a run over and see one"; and we did.

This engine proved to be a 30x40-in. first-motion, Corliss equipped with a 10 to 13-ft. double conical drum, a steam reverse, a steam brake and a dial indicator.

"This," said Hunter, "is a Vulcan Corliss hoisting engine. The real distinction between it and other Corliss engines is that instead of a rocker-arm for operating the steam valves, as in ordinary practice, a link is attached to a rocker-arm so that the engine's rotation can be reversed. It is equipped with the regular Corliss valve-gear in other respects. The steam and exhaust valves are operated by the same rocker-arm and link. Corliss engines are becoming more numerous about the mines, especially at the breakers, and some of them are of the reversible type."

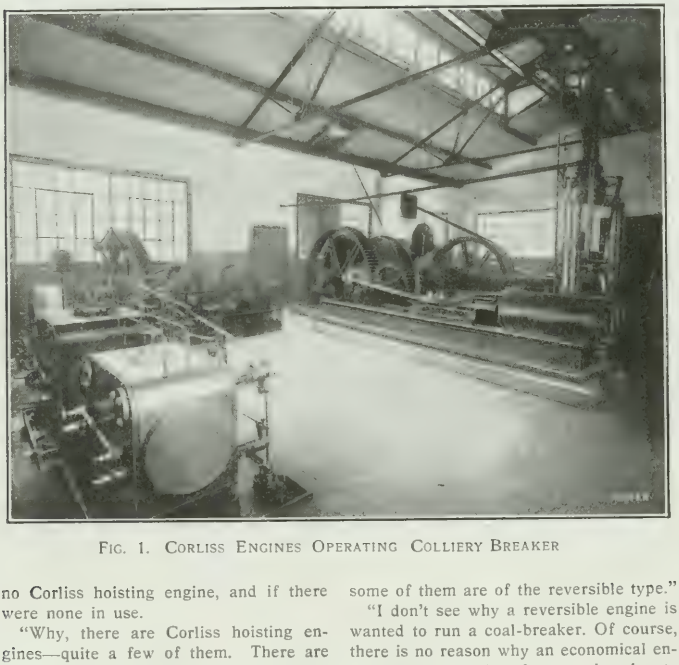


Fig. 1. Corliss Engines Operating Colliery Breaker

"I don't see why a reversible engine is wanted to run a coal-breaker. Of course, there is no reason why an economical engine should not be of as much value to a coal company, for what coal it does not burn it can sell."

"You remember this engine room, don't you?" replied Hunter, as he picked up the photograph shown in Fig. 1. "We found a tandem Corliss engine driving the breaker shakers, a geared hoisting engine for drawing the loaded mine cars up into the breaker. The third engine, which was a link Corliss and could be reversed, was used to run the breaker rolls and conveyors."

"Why should there be any call for reversing this engine?" I asked, for, to my in-experienced mind, this was all straight work and called for no reversing of the machinery.

"Frequently the men find it convenient to reverse the rotation of the rolls or conveyor when they become clogged, as they do sometimes. Then the reversing engine comes in handy."

"I see. Well, go on with your sermon." Hunter grinned and took up the thread of his talk.

"The governor of the Corliss hoisting engine is so arranged that it can be thrown out of adjustment and a partial movement of the throttle valve throws the cutoff motion into gear. This allows the engineer to start the loaded cage at the bottom of the shaft with steam admitted at nearly full stroke of the engine. Then, after the engine has made two or three revolutions, the throttle lever is thrown over to its full travel and the cutoff becomes operative; that is, the steam valve closes when the latch blocks are disengaged, the same as in the case of an ordinary Corliss engine."

"This engine seems to run easily and at a good speed," I remarked, as the engineer started to hoist.

"There is no reason why it shouldn't," replied Hunter, as he wiped his hands with a piece of colored waste. "The regular rate of hoisting with this engine is 105 mine cars per hour and a record of 925 cars has been made in eight hours, I am told."

Hunter Explains the Corliss Link Motion

As the engine was in operation most of the time, Hunter suggested that I visit the Vulcan works, where I could get a better idea of the construction of the engine and also obtain photographs of the link and valve-gear, which I did. When we returned to the hotel, I invited Hunter to my room, as I wanted further information regarding the operation of the valve-gear of which I had also obtained photographs, and Hunter readily consented to enter into an explanation. I often wonder how he had the patience to answer all of my questions.

Governor and Link

The first photograph he took up, shown in Fig. 2. "This," said he, as he dropped comfortably into a rocking-chair, "shows the valve-gear, governor and link arrangement. The rods connected with the steam and exhaust valves are connected to a rocker-arm which receives its motion from the link block as it is actuated back and forth by the link and

eccentric rods. By changing the position of the link, the travel of the link block is made either longer or shorter, which reacts back to the valve-gear and controls the opening of the valves when the governor is not controlling the point of cutoff. The one governor controls the valve-gear of both cylinders by means of a governing rod running from one engine to the other.

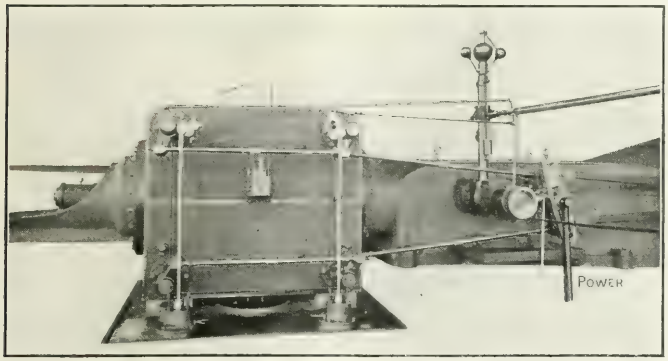


FIG. 2. VIEW OF VALVE GEAR, GOVERNOR AND LINK

"The governor is thrown out of action by means of a lever which is connected by a link to a camshaft, as you will notice in the other illustrations."

I looked at the photographs represented in Figs. 3 to 7 and nodded assent, for the cam arrangement was plainly shown.

"Since the governor is controlling," continued Hunter, "the cam is in a neutral position, and the cam arm to which the rod connecting to the governor is attached is out of contact with the cam. This position is shown in Figs. 3, 4 and 6. The position of the cam is also shown when the engine is running forward and running reverse in Figs. 4 and 6. This position of the link is also shown for the two directions of rotation.

"Now, take Fig. 3; what will the engine do with the governor and link set as shown?"

I studied the picture a moment and then said that the engine would either be at rest after running forward or was running slowly forward throttled, with no cutoff, but with the governor in control.

"Pretty good for a beginner," laughed Hunter; "in fact, that is just the condition. Now Take Fig. 4; conditions are the same, aren't they?"

I studied Fig. 4 and decided that Hunter would make an excellent examiner up in Masachusetts. Apparently, the illustrations were the same, but a closer examination showed that the cam arm was now in a lower position and the governor in a higher plane, which would indicate an earlier cutoff than shown by Fig. 3. The direction of rotation would be the same and the governor would control the cutoff. This is what I told Hunter, who replied: "Right again. Now let's try our luck on Fig. 5."

"To all appearances," said I, "this illustration shows that the engine was running reverse, but a second look shows that the engine is running forward, although the link is shown in the reversed position. This being the case, the engine is running full speed forward, the direction of rotation being shown by the arrow at the governor pulleys. The governor is out because the cam has lifted the rods connecting with the governor and the latest cutoff is taking place.

"I see what is occurring!" I exclaimed, as a light began to dawn. "The engine is in a plugged condition; that is, it is running forward, but steam is being admitted so that the piston meets live-steam pressure as it nears the end of its stroke."

"That is what takes place," replied Hunter. "In Fig. 6 the engine is shown running full speed in a reversed position, with the latest cutoff taking place, the governor controlling. In Fig. 7 the engine is shown running full speed reverse, but no cutoff occurs, as the governor is out of action."

"Do these engines run condensing?" I asked, as no mention had been made regarding the matter.

"No; in fact, none of the hoisting engines I have seen run condensing and, so far as I am aware, no attempt has been made to run them so in this country. You see a winding engine is operated intermittently and often under extreme variation of power. Therefore, the problem of condensing is rather complicated.

"I did read about ten years ago where a condensing hoisting plant was outlined, but the idea has never been given a practical test, so far as I know. As I remember, the general arrangement was to have a central condensing chamber with an air pump operated from the engine. There was also a second air pump which ran continuously, regardless of whether the engine was in operation.

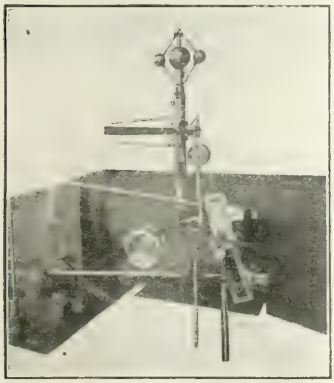


FIG. 3. AT REST AFTER RUNNING FORWARD OR RUNNING FORWARD SLOWLY, NO CUTOFF GOVERNOR CONTROLLING

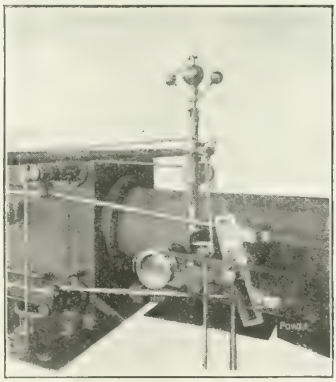


FIG. 4. RUNNING FORWARD AT FULL SPEED, EARLIEST CUTOFF GOVERNOR CONTROLLING

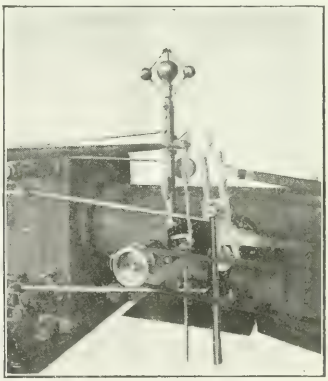


FIG. 5. PLUGGED, RUNNING FORWARD AT FULL SPEED, LATEST CUTOFF, GOVERNOR OUT

This air pump was used to maintain a vacuum while the main vacuum pump, which was attached to the engine, was at rest.

"A continuous injector and steam supply were to be maintained at the continuously operated air pump, but the injection water supplied to the intermittently operated air pump was controlled by the throttle-valve lever; that is, it was to be shut off and turned on to the engine condenser simultaneously with the steam.

"The pump that was to be in constant use was to give a regular supply to an accumulator injector tank, and while the winding engine was operating this water supply was to pass directly to the engine condenser, but its flow would be stopped by a connection in the main steam valve at the same time it was closed.

"When this was done, the water supply was to be forced into the accumulator against the pressure built up by its own volume, there being no means for the air to escape until an excessive pressure was reached. As soon as the steam throttle valve was open the injection valve was also open and the water in the accumulator, being under pressure, would flow and act immediately on the condenser and so eliminate any chance of losing the vacuum before the main injector supply could get into action."

"It might work out," I remarked, as Hunter flicked the ashes from his cigar, "but it looks somewhat complicated."

"Well, I don't think the idea ever was put into practice, at least in a commercial way. There have been and are condensing engines at collieries, but the character of the winding work makes it difficult to apply the practice of condensing in such a manner as to attain the highest efficiency or economy."

With these remarks, Hunter threw his partly consumed cigar away and bade me good night, leaving me to wonder if there were many engineering subjects which he did not understand.

Rapid Engine Alignment

By F. C. Holly

In no part of the erection of an engine is there more necessity for the exercise of skill than in its alignment.

The methods I use may not be original and may not be the best, but are an improvement over some that I have often seen employed.

A moderate-sized horizontal, girder-frame Corliss engine is to be erected. This type is selected because it is perhaps the most nearly representative of engine-aligning work in general and embodies all the principles of lining and leveling encountered in erecting horizontal engines of any type or size.

The first step after the engine is assembled is to provide suitable devices to hold a line in the exact center of the cylinder. For the head end a very familiar device for the purpose is the iron bracket shown in Fig. 1. By having the nut only partly tight, the bracket may be tapped with a hammer in the direction necessary to bring the line to the center. Another device is shown in Fig. 2, no forge or blacksmith being required to make it. A strip of soft wood ¾x1½ in. is cut the right length to drive firmly into the counterbore. A ¼-in. hole is bored through the stick at the middle and a piece of tin about 1¼ in. square with two opposite corners bent as shown is driven into the stick over the hole. The center is then scribed on the tin, a sharp-pointed hermaphrodite compass being used for the purpose, and a hole the size of the line pricked, through which the line is passed. Usually when the line is stretched and centered in the gland it will be found accurately centered in the counterbore, but, if not, a very light tap with the hammer up or down on the stick or of a flat tool sideways on the tin will suffice to make it so.

For holding the line in place at the crank end an efficient device is shown in Fig. 4. This, being attached to the frame and extended to clear the crank, will serve both in the testing of the cylinder for alignment to the frame and the squaring of the crankshaft to the center line.

A method I have often seen used is shown in Fig. 3. As this is attached to the floor and any movement or adjustment of the engine frame makes necessary the re-centering of the line in the cylinder, it is evident that much time is lost in this manner unless the engine must be set to this particular line. For centering the line a soft pine stick about ¼ in. in diameter, with common pins driven into each end, makes a very satisfactory tram. The pins can be driven in to suit the most refined adjustment and when lightly held between the first finger and thumb the slightest touch on the line can be plainly felt.

In squaring the crank to the line an ordinary rule, its end held against the crank face, will be found superior to either tram or calipers.

In leveling the frame and cylinder only six wedges are needed. These, when placed as shown in Fig. 4, illustrate a principle in wedging that can often be used to advantage. By driving wedge

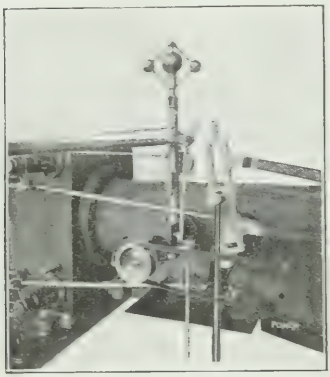


Fig. 6. Running Reversed at Full Speed, Latest Cutoff Governor Controlling

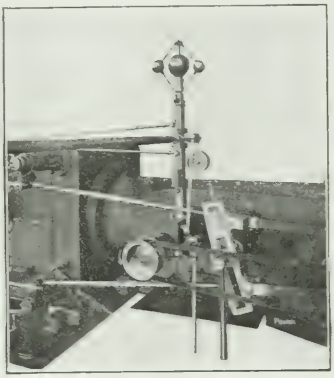


Fig. 7. Plugged Reversed at Full Speed, No Cutoff, Governor Out

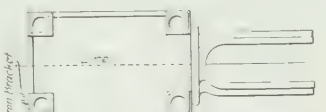


Fig. 1. Bracket for Holding Centering Line

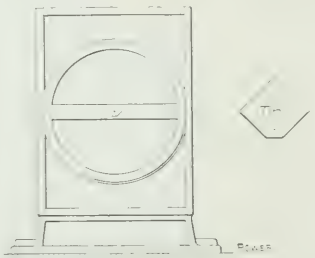


Fig. 2. Another Centering Line Support

Fig. 3. Holding the Line at the Crank End

A, *B*, *C* and *D*, the engine can be leveled lengthwise, while by lateral wedges both the cylinder and frame may be leveled crosswise, *A*, *B*, *C* and *D* acting as rests upon which the weight is practically balanced. Excepting in very heavy work, a multiplicity of wedges should be avoided.

After the lining up and leveling are completed, a wedge or tight-fitting shim should be placed under the frame near each anchor bolt and the nuts drawn tight enough to prevent the possibility of the alignment being disturbed while the engine is being bedded. This is especially important if a rust joint is used, as this style of joint is tightly rammed under the frame and cylinder feet and the ramming is certain to throw the frame out of line vertically if it is not snugly bolted down.

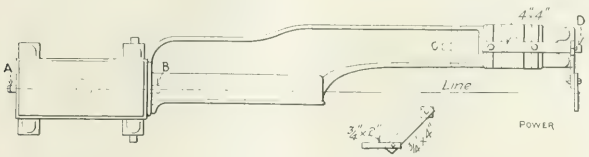


FIG. 4. ARRANGEMENT OF LEVELING WEDGES

Saving by Heating Boiler Feed Water

BY W. M. WRIGHT

Every heat unit added to the feed water before entering the boiler which does not come directly from the coal means a saving.

To readily determine what percentage of saving may be effected by the installation of apparatus to heat the water, the accompanying chart may be used.

It is noticeable that the higher the initial temperature of the water, the greater will be the percentage of saving for a given increase in temperature. For instance, the chart shows that in heating the water from 50 to 100 deg. temperature there is a saving of 4⅞ per cent. and that in heating it from 150 to 200 deg. a saving of 4⅞ per cent. is made.

To use the chart, read horizontally from the final temperature of the water to the diagonal line leading from the initial temperature and then vertically downward to percentage scale. This chart is calculated for 100 lb. boiler pressure. For 50 lb. pressure, percentages are less than 0.15 higher. For 200 lb. pressure, percentages are less than 0.2 lower.

Repairing Boiler Tubes

BY JOHN BURNS

Nothing is more discouraging to the engineer than to discover a bagged plate when the boiler is taken out of service, or in the case of a water-tube boiler, a number of bulged boiler tubes. In most cases, the primary cause is oil or grease in the feed water, or the use of a feed water that leaves a gummy deposit of the nature of soapstone or mica.

The writer's experience with defects of this kind has until recent years been confined to the horizontal return-tubular boiler, but the purpose of this article is to extend the practice to the driving or rolling back of bulges on boiler tubes, thereby saving the tube and the cost of

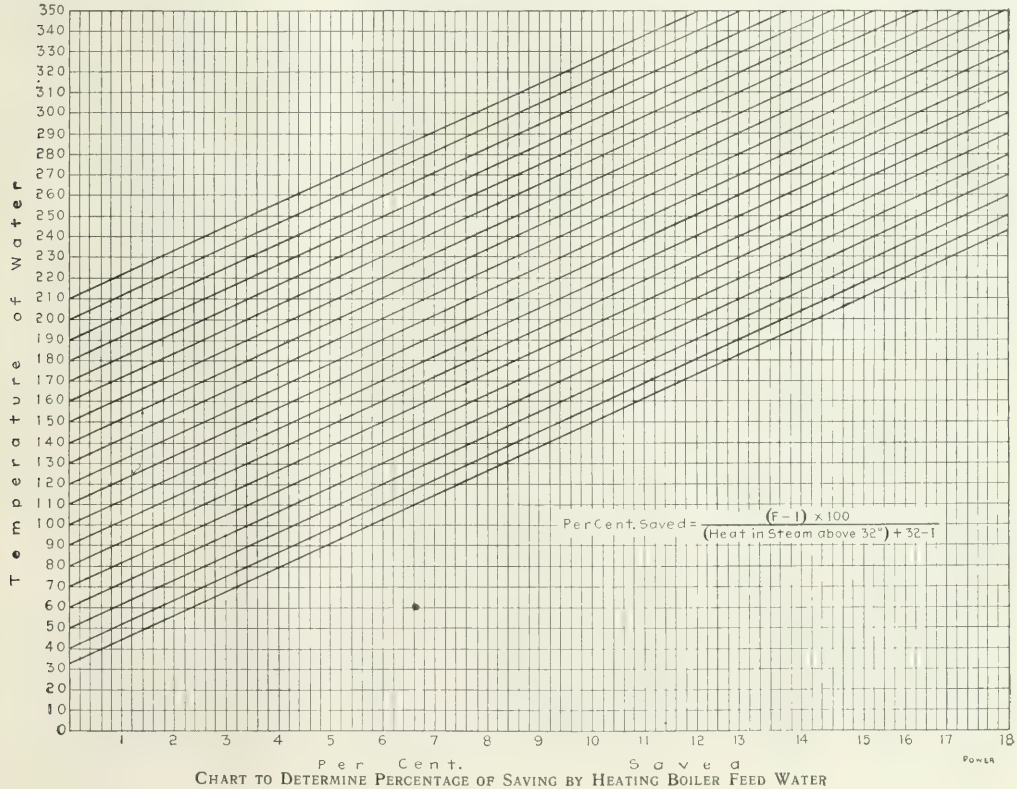
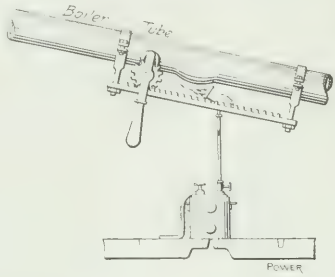


CHART TO DETERMINE PERCENTAGE OF SAVING BY HEATING BOILER FEED WATER

removal. It has been the custom with water-tube boilers to allow bulged tubes to remain in this condition until the bag bursts and a stream of water is discharged which threatens to put out the fire.

I have in mind an instance where a large town in West Virginia was without electric service an entire week on account of bulged boiler tubes. Some time ago the writer had an experience that came very near being as disastrous; in this case the trouble was caused by oil in the feed water. When two boilers were taken out of service for their usual cleaning the attendant discovered that nearly every tube in the bottom rows of the boilers were bulged and some of the tubes in three or four places; in fact, it looked as though another day's firing would have completed the destruction of the entire bottom rows of tubes. The boilers had been in service but six months. The loss of so many practically new tubes was disheartening, but something had to be done, and done quickly, as the other boilers were doubtless in the same condition.

We secured a large gasoline blow-torch of the furnace type and the blacksmith was instructed to make a swage that would exactly fit the circumference of the tube. The boilers were drained out, and with a sledge, after heating, we started driving back the bulges. I wish to say right here that this was no pink tea, for at every blow of the sledge we were treated to a shower-bath of soot and ashes. However, we made fairly good



ROLLING BACK THE BULGES

progress until it was discovered that the blows from the sledge hammer were having a bad effect on the tube ends where they were expanded into the headers. The clamps and roller shown in the accompanying illustration were then devised, and with an extension blow pipe about 4 ft. long so that the torch could rest on the grate bars while heating was taking place, we again started operations, and this time with better results. We heated and rolled back all of the bulges; the tubes were made as good as new. In fact, the operation was performed on one tube that was bulged so badly that it had started leaking; this same tube was removed a year later.

It should be understood that the plant is in operation 24 hr. a day, and by a little careful watching and making repairs as described, we have lost but nine tubes since the plant was started in 1908, an average of less than three tubes a year. It might be added, however, that an asbestos-lined hood of sheet iron, made to fit around the tube with a hole in the bottom to admit the flame of the blow-torch, greatly facilitated the heating. Later I thought so much of the device that I had it patented, not for the purpose of preventing the use of the roller method of repairing tubes by engineers, but to derive some revenue from parties who should undertake to manufacture and market it.

Deterioration of Coal in Storage

By A. Bement*

Results of tests of coal exposed to the weather for one year to determine the deterioration due to change in weight and in its heating power.

*Consulting engineer

In POWER, Jan. 2, an article under the above title by H. C. Porter and F. K. Ovitz discussed investigations of coal deterioration, and referred to experiments made by the present writer. As a matter of further information, the results of these tests are here given in some detail.

The tests included determining the change in heating power, the change in weight and the tendency to disintegrate by slaking.

The character and quality of the four kinds of coal tested are shown by Tables 1 and 2. How one year's storage out of doors affected heating power and weight is shown in Table 3, and the results of tests of the second best and poorest coal under water, in Table 4. Table 5 shows the disposition to disintegrate into smaller pieces.

During the last few years the writer has made several investigations. The first consisted in experiments to ascertain the loss in heating power only. While that work was largely preliminary, it indicated that the loss in heat value is much smaller than generally supposed. At the end of the first year's work, it was decided that change in weight of fuel is also important, so the second year tests of this were included. While the work gave useful results and developed an accurate method of testing, it was really preliminary. Then with the benefit of two years' experience, another series of tests was planned and carried out very successfully.

The greatest difficulty was accurately determining the change in weight. Under common conditions of weather exposure a sample may increase in quantity by collecting dust and dirt blown into it by the wind and decrease by losing small particles carried away by rain and wind.

To isolate these effects, coal containing no dust was selected, placed in a box large enough to hold 400 lb. and covered with cheesecloth to catch dirt. Drainage from the box was caused to flow at low velocity through a trough containing dams or riffles to catch any dust carried out with the water. All of the coal in the sample passed over a screen having ¼-in. round perforations and through another with ⅝-in. perforations. This sample in an air-dry state was carefully rescreened over ⅜-in. perforations, eliminating all small stuff and leaving clean coal of uniform size, which was then sampled and analyzed. The remainder was weighed and placed in storage in the box.

When the coal was removed from storage its weight was taken, after which it was sampled and again analyzed. The heating-power determinations were made with a Mahler calorimeter at the same time the analyses were made. In determining the change of weight, calculations were based on the same moisture content initially present in the coal. This was because coal increases and decreases in moisture content independently of any change that may affect the ash content or that of the coal proper. Thus the final weight of the dry coal referred to

TABLE 1. PROXIMATE COMPOSITION OF COALS

	Coal A	Coal B	Coal C	Coal D
Moist coal				
Moisture, per cent	6.75	9.65	12.66	14.38
Ash, per cent	7.23	10.99	10.75	10.01
Volatile matter, per cent	35.36	31.55	37.23	36.23
Fixed carbon, per cent	50.66	47.81	39.36	39.38
Heating power in B.t.u.	12,944	11,178	10,990	10,774
Dry coal				
Ash, per cent	7.75	12.16	12.31	11.69
Volatile matter, per cent	37.92	34.92	42.63	42.32
Fixed carbon, per cent	54.33	52.92	45.06	45.99
Heating power in B.t.u.	13,882	12,803	12,583	12,584
Pure coal				
Volatile matter, per cent	41.11	39.75	48.61	47.92
Fixed carbon, per cent	58.89	60.25	51.39	52.08
Heating power in B.t.u.	15,048	14,575	14,350	14,250

its initial weight gave the change due to weathering.

The tendency of coal to disintegrate by slaking down to smaller sizes was considered sufficiently important to test carefully. A goodly number of average lumps of coal from each of the kinds were placed in outdoor storage for one year after being weighed. These lumps were so placed that the portion scaling off remained associated with the original lump. At the end of the year what remained intact of the original lumps was weighed, and the total weight referred to the original weight gave the percentage of the original lump that was not disintegrated. The slaked-off portion was separated into sizes each of which was also weighed, so that in addition to knowing to what extent the sample remained as lump, it was found into what sized pieces the disintegrated portion was disposed to separate.

TABLE 2. ULTIMATE COMPOSITION OF COALS

	Coal A	Coal B	Coal C	Coal D
Carbon, per cent.	81 81	81 63	77 23	75 74
Hydrogen, available, per cent	4 24	4 02	4 02	3 63
Sulphur, per cent.	2.04	2.14	4.45	5.24
Nitrogen, per cent.	1.79	1.73	1.60	1.51
Water of combination, per cent.	10.12	10.48	12.70	13.88
Total	100.00	100.00	100.00	100.00
Heating power per pound in B.t.u	15,048	14,575	14,350	14,250

TABLE 3. CHANGE DUE TO EXPOSURE IN AIR FOR ONE YEAR

Coal	Change in Per Cent. Heating Power	Weight	Total
A	— 0 25	0 00	— 0 25
B	— 0 38	+ 0 11	— 0 27
C	— 0 93	— 1 15	— 2 08
D	— 1.85	— 2.29	— 4 14

TABLE 4. CHANGE OCCURRING UNDER WATER, ONE YEAR'S STORAGE

Coal	Change in Per Cent. Heating Power	Weight	Total
B	+ 0 02	— 0 81	— 0 73
D	— 0 44	— 0 35	— 0 79

TABLE 5. DISPOSITION TO SLAKE

Disposition of lump coal to slake down to smaller size. Exposure of one year. Original samples 100 per cent. lump, which in one year's outdoor storage broke down to sizes as shown.

Coal	Percentage of Each Size After One Year: Lump	Egg	Sizes 1- and ½-in. and under
A	100 00	00.0	00 00
B	87 84	00 0	12 16
C	35 49	23 0	41 51
D	18.36	16.5	65.14

Chart for Determining Blowing Engine Speed

By J. C. Watson

It often happens in blast-furnace work that the air for the furnaces is supplied by two blowing engines of different sizes. As it is necessary for satisfactory operation to supply a definite amount of air to each furnace, this involves a calculation of the speed at which the engines should run to deliver the required amount. A convenient way of determining these speeds without any calculations is by the use of a chart similar to the one shown herewith in Fig. 2. This chart is constructed as follows: Suppose that the blast furnace to be supplied uses not less than 30,000 nor more than 45,000 cu.ft. of free air per minute, and that the air is supplied by two blowing engines, one having a maximum speed of 75 r.p.m. and delivering 400 cu.ft. of free air per revolution, the other having a maximum speed of 100 r.p.m. and delivering 350 cu.ft. of free air per revolution.

Take a sheet of cross-section paper, as shown in Fig. 1; divide the left side into 75 equal parts, with the zero at the top to represent the maximum 75 r.p.m. of the 400-cu.ft. blowing engine. At the right side of the sheet choose another vertical line, and starting with the minimum number of cubic feet of air required per minute at the bottom of the sheet, divide this line into such a number of equal parts that the maximum number of cubic feet of air per minute will be shown on the sheet. It is immaterial whether this comes at the top line of the sheet or not; convenience in making the divisions will determine.

All that remains to be done to complete the chart is to determine the location of the line representing the 350-cu.ft. engine and the size of its divisions. In the present case the 400-cu.ft. engine, making 75 r.p.m., will pump 30,000 cu.ft. of air per minute, so the zero speed of the 350-cu.ft. engine lies somewhere on the line connecting these two points.

Now, if the 350-cu.ft. engine runs at 100 r.p.m., it pumps 35,000 cu.ft. of air per minute. So, if the zero point on the 400-cu.ft. engine line is connected with the 35,000 point on the volume line, it will be known that the point representing 100 r.p.m. of the 350-cu.ft. engine line lies somewhere on this connecting line. Likewise, if the 400-cu.ft. engine is running at 20 r.p.m., it blows

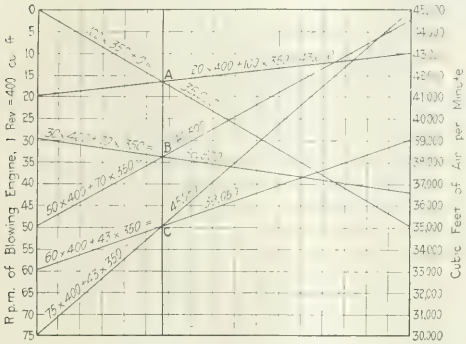


Fig. 1. Method of Locating Points on Chart

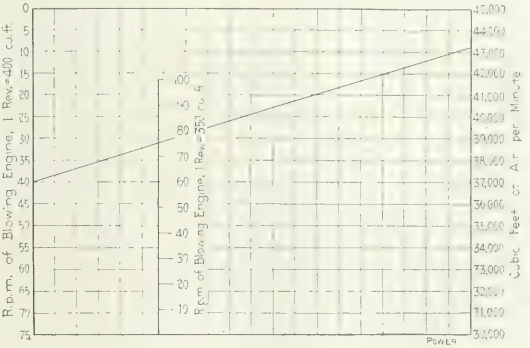


Fig. 2. Finished Chart, Showing Volume of Air Pumped

8000 cu.ft. of air per minute, and if this is added to the 35,000 cu.ft. blown by the 350-cu.ft. engine at 100 r.p.m., there is a total of 43,000 cu.ft. of air per minute blown by the two engines.

If, now, 20 is connected on the 400-cu.ft. engine line with 43,000 on the volume line, another line is located on which the point representing 100 r.p.m. of the 350-cu.ft. engine must lie. The intersection at *A*, Fig. 1, of the two lines determines the exact location of this point. The point of zero revolutions lies directly under this 100-revolutions point, so all that remains is to draw this line and divide it into 100 equal parts.

It is better, however, to locate a few more points, as *B* and *C*, in order to check the accuracy of the work. The completed chart is shown on Fig. 2.

Suppose that 42,250 cu.ft. of air per minute is required by the furnace, and that it is desired to run the 400-cu.ft. engine at 40 r.p.m.; then connect these two points with a straight-edge, as in Fig. 2, and it will be found that it crosses the 350-cu.ft. engine line at 75. This means that in order to attain the required result, this engine must be run at 75 r.p.m.

Water in the Low-Pressure Cylinder

By H. R. Low

Low-pressure cylinders of compound engines are not infrequently wrecked by water which is usually supposed to come from the condenser. The article shows how it may be brought over from the boiler in quantities too small to fill the high-pressure clearance and accumulate in the receiver until swept into the low-pressure cylinder.

It not infrequently happens that a compound condensing engine which has hitherto been well behaved and given no trouble to speak of will suddenly take a dose of water into the low-pressure cylinder, resulting in a wreck of greater or less magnitude with all its attendant disagreeable features: loss of the unit in service, a repair bill, a disgruntled owner and superintendent and a sore engineer to whom everybody is looking for an explanation. Almost the first question asked upon such an occasion is, "Where did the water come from?"

There are many who fail to understand how it is that the low-pressure piston can and does act as a pump and pull the water over into the low-pressure cylinder; not from the condenser, but from the boilers. In the opinion of many, the condenser is a sort of suspicious character and the first to be blamed as the only source that they can see from which the water can come. But "How," they ask, "does the water get through the high-pressure side without wrecking it?"

Perhaps a few minutes spent in the consideration of this subject may prove instructive and profitable, for having once found and understood the cause we may be better able to use means of prevention against further similar mishaps.

As most of the wrecks that have come to the notice of the writer have happened to engines of the cross-compound condensing type, assume an engine of this sort with the low-pressure cylinder twice the diameter of the high, in which case it will have four times the area and volume, since the stroke is the same. Let the initial pressure be 150 lb. absolute and the cutoff on the low-pressure fixed for one-third stroke.

Supposing the engine to be running with a fair load—say, cutting off at quarter stroke on the high-pressure cylinder—and that the pressure varies inversely as the volume, the pressure at the end of the stroke of the high-pressure cylinder will be

$$150 \div 4 = 37.5 \text{ } lb.$$

as at *A* in Fig. 1. The volume of the high-pressure cylinder is one-quarter that of the low. If the low-pressure cut off at one-quarter stroke it would take the same volume out of the receiver at each stroke that the high-pressure cylinder delivered to it. The receiver pressure would be the same as the high-pressure terminal and the high-pressure diagram would end in a point.

But the low-pressure cylinder cutting off at one-third stroke takes a larger volume out of the receiver at each stroke than the high-pressure cylinder delivers to it. The steam at this greater volume has a correspondingly less pressure. Whatever happens to it in the meantime, when the steam has been expanded to the end of the stroke in the low-pressure cylinder it will have four times the volume that it had at the end of the high-pressure stroke because the low-pressure cylinder, into which it is delivered and ultimately expanded, is four times as large as the high.

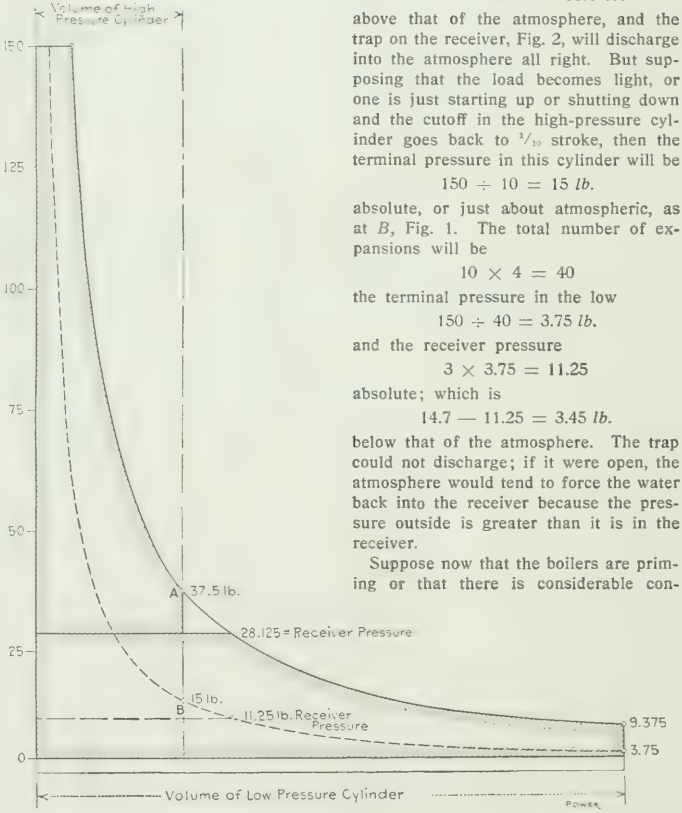


FIG. 1

If it had already been expanded four times in the high it would be expanded

$$4 \times 4 = 16$$

times in all and the terminal pressure in the low would be

$$150 \div 16 = 9.375 \text{ } lb.$$

With the cutoff at one-third, the initial pressure in the low (the receiver pressure) will be

$$9.375 \times 3 = 28.125 \text{ } lb.$$

An ideal diagram for the high-pressure cylinder drawn to the same pressure scale as the low, but shortened to one-quarter, the length of the low-pressure diagram would look like the upper part of Fig. 1 while the lower portion would represent the ideal low-pressure diagram.

In this case the receiver pressure is

$$28.125 - 14.7 = 13.4 \text{ } lb.$$

above that of the atmosphere, and the trap on the receiver, Fig. 2, will discharge into the atmosphere all right. But supposing that the load becomes light, or one is just starting up or shutting down and the cutoff in the high-pressure cylinder goes back to $^1/_{10}$ stroke, then the terminal pressure in this cylinder will be

$$150 \div 10 = 15 \text{ } lb.$$

absolute, or just about atmospheric, as at *B*, Fig. 1. The total number of expansions will be

$$10 \times 4 = 40$$

the terminal pressure in the low

$$150 \div 40 = 3.75 \text{ } lb.$$

and the receiver pressure

$$3 \times 3.75 = 11.25$$

absolute; which is

$$14.7 - 11.25 = 3.45 \text{ } lb.$$

below that of the atmosphere. The trap could not discharge; if it were open, the atmosphere would tend to force the water back into the receiver because the pressure outside is greater than it is in the receiver.

Suppose now that the boilers are priming or that there is considerable condensation—as there is apt to be on starting up—and water accumulates in the receiver as shown in Fig. 2. When the

low-pressure piston moves away from the head the steam from the receiver flows into the space which it leaves. If the water ever gets so high as to cover up the opening at *A*, Fig. 2, the water would be forced up the pipe *C* with a force equal to the difference between the pressure in the receiver and that in the vacuous space which the piston left behind it.

It would not be necessary for the water to become high enough to completely shut off the space at *A*, for when this opening became restricted the inrushing steam would cause the water to surge until it filled the section at the elbow and up would go a slug of water to the cylinder. It takes only a trifle more than enough to fill the clearance to do the damage.

The same thing may happen all the more readily at full load if for any reason the traps fail to work, because there will be a greater pressure difference between the receiver and the low-pressure cylinder when the piston starts off and a more lusty flow to carry the water over.

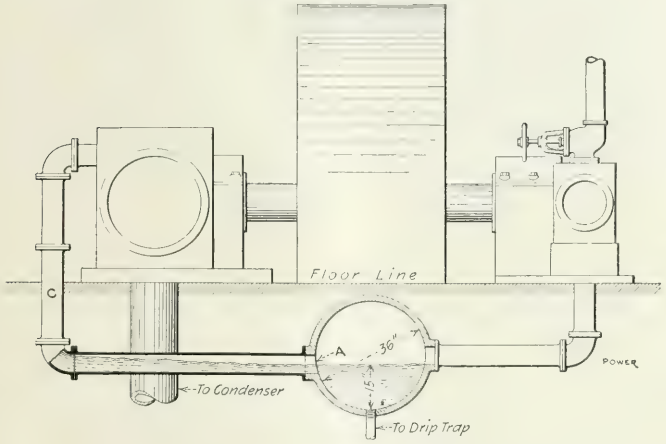


FIG. 2. HOW WATER GETS INTO THE LOW-PRESSURE CYLINDER

Fig. 2 is drawn to scale from an engine with which I am well acquainted and there are many more similarly arranged.

When I start up a compound engine I always shorten the cutoff on the low-pressure cylinder to build up the pressure in the receiver and keep the trap working until the engine gets its load; then I set the low-pressure cutoff ahead and let the receiver pressure down to what I want to carry.

A Swedish inventor claims to have devised means for burning pulverized peat in a locomotive as practically and economically as coal.

The total number of central stations in Germany is reported to be about 2700.

Centrifugal Pump Troubles

By F. Webster

Centrifugal pumps do not produce an over-rise of pressure; hence there are no shocks or disruptive stresses. On the other hand, each type of pumps has its peculiarities, and the operator must study them in order to be master of the situation.

The ordinary size of centrifugal boiler feeder runs at about 3600 r.p.m., and when in order it is perfectly silent and free from vibration. Sometimes it will run for months with practically no attention save the inspection of the oiling and cooling systems, but when it does get out of order a diagnosis must be made and a cure attained.

Ailments

Different ailments are contracted by this type of boiler feeders. One power-plant engineer has found that getting out of balance is the most serious, the affection generally coming on instantly and changing the conditions suddenly from perfect running to a noisy vibration; then there is nothing to do but shut down and dismantle the machine.

In two cases a sprung shaft seemed to be the trouble, and it seemed idle to try any scheme for getting the rotor in balance except by putting in a new shaft and a set of new bearing sleeves. This method produced a cure, and gave the diagnosis after the prescription had been tried. Hence, the rule in case of trouble is to get new parts.

Out of Balance

That a rotor getting out of balance will cause a breakdown is accepted, but the cause of its getting unbalanced is not always clear. In the investigation of a recent case of sprung shaft a clue appeared in a little sliver of babbitt weighing probably less than ½ oz., which was found lodged in the groove between the outer edge of the driving disk and the ring carrying the steam vanes of the turbine, as shown in the illustration. This babbitt came from the shaft bushing, having broken from a spongy place in the casting. The unbalancing effect of this small piece—or by whatever else it may have been caused—was instantaneous. There were no immediate steps in the breakdown; the machine went at one leap from perfection to destruction.

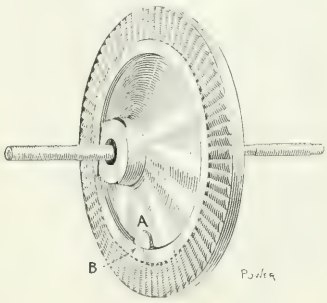
Centrifugal Force

Calculation relates to the theory of the unbalancing effect of any given weight would be that the centrifugal force equals

$$F = \frac{WV^2}{Rg}$$

where

$W = \frac{1}{2}$ oz. $= \frac{1}{32}$ lb.;
$R = 10$ in. $= \frac{5}{6}$ ft.;
$G = 32.16$;



BABBITT LODGED ON IMPELLER

V = Velocity in feet per second.
For an r.p.m. of 3600, V will equal

$$\pi \times \frac{5}{6} \times 2 \times 3600 \div 60$$

and

$$F = \tfrac{1}{32} \times (3.1416 \times \tfrac{5}{6} \times 2 \times 3600 \div 60)^2 \div \tfrac{5}{6} \times 32.16 = 115 \text{ lb.}$$

This unbalanced weight would be applied as a concentrated load at the middle of a shaft, probably 3 ft. or so long. The theoretical deflection with a 1½-in. shaft would be about 0.01 in., according to the formula

$$f = \frac{Wl^3}{48EI}$$

where

W = Weight in pounds;
l = Length between the bearings in inches;
E = Coefficient of elasticity, which for steel is 30,000,000;
I = Moment of inertia in inches of the shaft.

For a 1½-in. shaft $I = 3.08$. The actual deflection may be much greater.

Electrical Department

Conducted to be of service to the men in charge of electrical equipment in the power house

Rotary Converters and Their Operation

By Norman G. Meade

A rotary converter combines in one machine the functions of a motor and generator, and forms the electrical connection between an alternating and a direct-current system. As usually installed, it acts as a synchronous motor driving a direct-current generator, but it can be inverted so as to consist of a direct-current motor driving an alternating-current generator. If mechanically driven it will supply both direct and alternating currents.

In construction a rotary converter is similar to a direct-current generator, with the addition of suitable collector rings connected to the armature winding at points having the proper phase relation. It can be built for single-, two-, three- or six-phase circuits, but single-phase converters are seldom employed. Transformers are generally interposed between the converter and the alternating-current system to lower or raise the voltage. This is usually necessary, owing to the fixed relation between the direct- and alternating-current voltages of the converter, and the desirability of high-tension transmission.

Classification of Rotary Converters

To illustrate its performance let Fig. 1 represent the rotary converter armature revolving in a two-pole magnetic field, two poles being chosen for simplicity. If the machine be equipped with both a commutator and collector rings, it may be run as an ordinary direct-current motor. The conductors on the revolving armature will be cutting lines of force exactly as though the armature were revolved mechanically; alternating currents will therefore be obtained from the collector rings. If the operation be reversed and the machine run as a synchronous motor, the alternating currents will be transformed to direct current.

By connecting four equidistant points of the winding to four collector rings, as in Fig. 2, two-phase or quarter-phase currents will be obtained and there will be two pairs of conductors in the alternating-current line. By connecting three equidistant points of the armature winding as in Fig. 3, three-phase currents will be delivered. Since direct-current armatures have closed circuit windings, the connections on the alternating-current side of a three-phase rotary converter are always delta.

In most recent large installations, six-phase rotary converters are used, operated by double-star or double-delta connections from three-phase transmission lines. In six-phase rotary converters six equidistant taps are led from the armature winding to six collector rings, as in Fig. 4. Figs. 5 and 6 show respectively the alternating-current and direct-current sides of a standard six-phase rotary converter. The advantage of such a machine arises from its relatively lower armature copper loss. It is usually of large current capacity as the more complicated connections in the transformers and at the collector ring brush-holders outweigh the advantages in smaller machines.

The diagrams have shown two-pole rotary converters only. In practice multipolar machines are used to reduce the speed. With two poles only one connection to each ring was necessary. In multipolar machines as many connection to each ring are required as there ar pairs of poles.

The ratio between the potential at th alternating-current side and at the direc current side is approximately constar and cannot be altered by changing th speed or by using a field rheostat. Wit a sinusoidal curve of electromotive forc the following ratios of conversion ar approximated, the potential at the direc current side being taken as unity: I single- and two-phase machines the po tential at the collector rings will be 0.71 three-phase, 0.61; six-phase, 0.71, or 0.6 depending upon whether a star or double-delta connection is used. Thus two-phase rotary converter receiving a ternating currents at approximately 42 volts will deliver direct current at 60 volts, and a three-phase rotary converte with approximately 366 volts on the a ternating-current side will deliver a 600 volt direct current.

Fig. 1 Fig. 2 Fig. 3 Fig. 4

Elementary Rotary Converter Windings for Different Phases

Rotary converters can be used to sup ply three-wire systems, or to obtain tw potentials for operating variable-spee direct-current motors. For such circui a neutral wire is used in conjunctio with the positive and negative leads o the direct-current side. When two-phas distribution is used the direct-curre neutral wire can be connected to th middle point of the secondary coils o the transformers. Upon three-phase sy tems the transformer secondary coils ar connected in the interconnected star sy tem and the neutral is brought out fro the common junction point of the sec ondary coils.

The relationship between the numbe of poles, the speed and the frequenc of rotary converters is the same as tha of alternating-current generators; that i

the frequency equals the number of poles multiplied by the revolutions per minute divided by 120.

Hunting

A converter must run in synchronism with the generator supplying it, but if the speed of the latter is not uniform, the converter will tend to follow the fluctuations of the generator speed. If the generator speed increases, the converter will tend to acquire a similar relative speed, but the momentum of the moving armature carries it beyond this speed, after which it will retard, thus causing a surging action. This is commonly known as "hunting" and may assume disastrous proportions if not provided against. As hunting is an oscillation each side of the synchronous speed, the corrective currents set up by it flow first in one direction then in the other. The effect is to cause the magnetic field continually to shift back and forth across the pole face. A similar action also occurs in the generator. That hunting is always accompanied by a shifting field, makes possible an effective preventive. This is a heavy copper grid surrounding each pole piece and having its cross bars embedded in slots in the pole face. Acting as dampers, these grids prevent the relative position of the converter armature from being changed by the corrective currents more than the initial change in the generator.

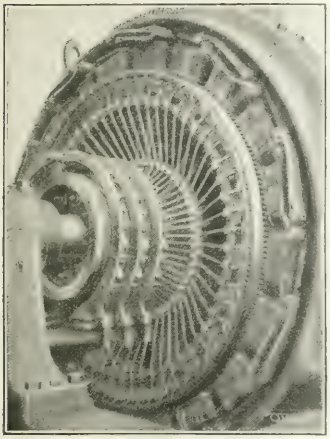


Fig. 5. Alternating-Current Side

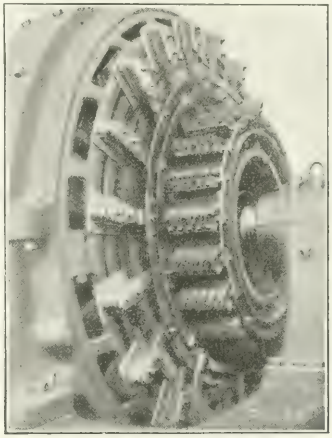


Fig. 6. Direct-Current Side

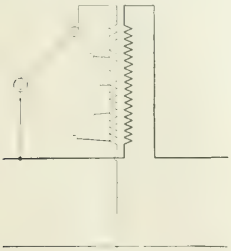


Fig. 7. Diagram of Potential Regulation

Voltage Regulation

Regulation of the direct-current voltage can only be obtained by changing the alternating-current voltage. The regulation can be nonautomatic by means of transformer loops, potential regulators, induction regulators or by the synchronous regulator or alternating-current booster. Automatic regulation is possible, within narrow limits, by using a series winding in the field, and with the necessary control apparatus the induction regulator and the synchronous regulator can be arranged to operate automatically.

Transformers designed for service with rotary converters have taps on both the high- and the low-tension windings, for obtaining small variations in voltage. This means of altering the potential, however, cannot be used while the apparatus is in service.

The potential regulator shown diagrammatically in Fig. 7 consists of a special transformer having the primary coil connected across and the secondary coil in series with the line. Several taps are taken from the primary coil to contact points on a faceplate or drum. A reversing switch is provided and the voltage can be increased or diminished without regard to the line voltage.

The induction regulator consists of a transformer, the primary coils of which are movable, with respect to the secondary coils. The core and winding construction resembles that of an induction motor. The primary coil is connected across and the secondary coil in series with the line. By shifting the position of the primary winding of the regulator, the voltage delivered to the alternating-current side of the converter can be raised or lowered without opening the circuit and the voltage on the direct-current side will be varied.

Still another method of regulation is to use an alternating-current generator having the same number of poles as the rotary converter and having its rotor mounted on the same shaft with the converter armature, between the armature windings and the collector rings. The regulator frame, with its pole pieces and field winding, is carried by brackets from the frame of the converter. This avoids brushes and collector rings for the regulator, and the main field winding of the converter is free from regulating devices. A converter of this type, manufactured by the Westinghouse Co., is shown in Fig. 8.

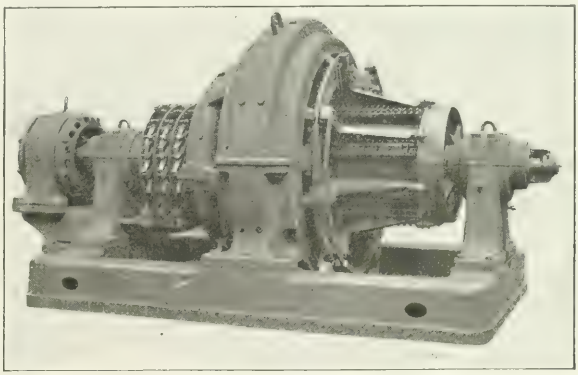


Fig. 8. Converter with Synchronous Regulator

With this regulator the direct-current voltage can be raised or lowered by altering the strength and polarity of the booster fields; a synchronous regulator rated at 15 per cent. of the capacity of the converter is capable of varying the voltage 30 per cent. This regulation

can be accomplished by hand or automatically and the regulator field can be controlled to maintain a constant potential or a constant proportion of the load on the rotary converter. The latter is particularly desirable when operating in parallel with other rotary converters or with storage batteries.

COMPOUNDING OF ROTARY CONVERTERS

The field strength of a rotary converter can be adjusted so that the direct-current output will be obtained with a minimum alternating-current input; varying the field strength either way will increase the input, while the output remains the same.

An over-excited field sets up a leading current in the line, and a lagging line current arises from an under-excited field. These changes in field strength do not appreciably affect the direct-current voltage, and the only way to vary the potential is to vary the alternating-current voltage at the collector rings, owing to the fixed ratio between the two electromotive forces. However, it is possible by proportioning the series excitation and providing sufficient inductance in the supply line to produce a change in the voltage at the collector rings. The conditions for rotary converter compounding are therefore, a series winding on the field and inductance in the line between the generator and the converter. The series winding does not directly increase the direct-current voltage but acts indirectly through the inductance.

A Low Record Rate for Electrical Energy

The city of Winnipeg, Manitoba, has established rates for commercial electric service that seem destined to outclass any efforts for low charges on the part of municipalities in the United States, including Pasadena, Calif., which for the past few years has practically held the record for a minimum consumption charge. With a municipally owned hydroelectric power plant on the Winnipeg River, the city has made a base rate of 3½c. per kilowatt-hour, with proportionate reduction for various classes of service.

The plant has a rated capacity of 32,000 hp., with available water power for the generation of about twice this amount. The power plant, transmission system (77 miles long), distributing lines and terminal station, were completed in October, 1911, at a cost of approximately $3,250,000. With this total investment, and a population of about 175,000, the city is earning suitable returns with the following rates of service:

Electric lighting: Base rate, 3½c., for store, factory and residence use. Discounts on bills of $50, or more, per month, ranging from 10 to 60 per cent. Minimum rate for residence lighting per month, 50c.; for business lighting, $1.

Electric heating and cooking, for domestic service: A separate meter is installed, with a rate of 1c. per kilowatt-hour. Minimum charge of 75c. per month.

Electric power: Rates range from 3½c. to 0.8c. per kilowatt-hour, the bills being subject to discount as noted.

LETTERS

Pilot Lamps

In some small isolated electric stations, the opening of the main circuit-breakers causes the entire plant to be plunged in darkness. In such cases considerable time and trouble can be saved by a slight change in the wiring of the lamps on the switchboard. By connecting one or two lamps directly to the generator leads (as is usually done in the larger stations), they cannot be affected by the opening of the main circuit-breakers, and sufficient light is left to enable the attendant to operate the board.

Not long ago a 600-kw. plant in a manufacturing establishment was shut down by a short-circuit, every breaker being opened. It took 15 min. to find a torch or lantern by which to see the meters and ascertain conditions at the switchboard before restoring the current to it. Meantime the engine room was in total darkness, and the running engines made it dangerous to move about.

Had a few or even one of the switchboard lamps been connected directly to the generator leads, current could have been restored to the board immediately.

I. C. CHAMBERLAIN.

Paterson, N. J.

Rebabbitting a Large Bearing

A short time ago we had a main bearing burn out on a direct-connected 500-kw. direct-current generator. As we had already experienced the high cost of having a similar bearing rebabbitted at a local shop, we decided to do the work ourselves.

This unit was the first of an incompleted installation and was already running two cars on a short piece of track, which depended upon it entirely for power. Consequently it was very essential to have the machine running as soon as possible. In order to remove the bearing, it was necessary to raise the armature and flywheel with the shaft. This was accomplished by means of two 25-ton jacks under the shaft and one 50-ton jack under the flywheel. The bearing was removed during the night and was ready for the shop by seven the next morning.

We had no metal mandrel nor means for turning up a wooden one and the best substitute was a short piece of pipe about 14 in. in dimaeter. This was brought to the proper size, the shaft being 15 in. in diameter, by wrapping pieces of asbestos paper around it, this paper also acting as a very good heat insulator. The bearing was in four pieces, a top and bottom and two quarter wedges, one piece being babbitted at a time in the following manner:

The piece to be babbitted was stripped of all old babbitt and heated to a very high temperature. It was then laid on a level floor; thin strips, about ¼ in. thick, cut from an old belt, were laid at the ends to obtain the proper thickness of babbitt and the pipe rested on these. The babbitt was then heated in two pots and poured in from both sides of the bearing. As the metal shrunk slightly upon cooling, it was necessary to keep pouring in a little metal until the space was entirely filled, and no more metal could be poured. After being scraped and the oil grooves cut, the bearing presented a very good appearance. The job was completed by two men in 9 hr., as against 3 days required in the former case and at about ¾ less cost. The bearing was replaced the same evening and outside of a slight scraping the next day, has proved entirely satisfactory.

Dover, N. J. J. M. BURNS.

Wattmeter Connections

Referring to Mr. Crateau's wattmeter connections in the issue of Apr. 23, I would submit the following explanation:

Meter No. 1 is apparently connected properly. Meter No. 2 has both current coils connected into the same phase. This is incorrect and will produce one of two possible results. Upon increase of field excitation the meter will slow down, stop and reverse; or will speed up rapidly, reaching a maximum speed of 173 per cent. of normal, depending on the phase into which the current coils are connected.

Of course, the solution is to connect the current coils into their proper phases. It should be impossible for meter No. 1 to indicate over half load. The synchronous motor, at full load and 50 per cent. power factor, will require somewhat less than 250 amperes per phase. This would require a current transformer of ratio 250: 5 to give full load indication on the meter. He is using one having a ratio of 500: 5 which naturally reduces the meter indication one-half.

Meter No. 2 is rated at 150 volts at five and ten amperes. With the potential transformer he is now using, having a ratio of 20: 1, he will get 110 volts, which is so much below the meter rating that I doubt if the meter will give dependable results. The meter should be used with a transformer of a ratio of 15: 1.

The current coils should have a ratio of 250: 5 and the five-ampere current windings should be used.

If these changes are made, the meter should check.

H. R. BODEMÜLLER.

Necaxa, Puebla, Mexico.

Gas Power Department

Worth-while gas-engine and producer information treated in a way that can be of practical use

Bituminous Producers for Power*

By C. M. Garland

In the development of the power producer for the gasification of fuels containing above 12 per cent. volatile matter, the manufacturers at an early date divided on the question of the method of handling this troublesome constituent and proceeded with their developments along two diverging lines. In one they sought to convert the condensible combustible constituent of the volatile matter into fixed combustible gases by drawing this product through either the whole or part of the incandescent fuel remaining after volatilization; in the other to separate the condensible portion from the permanent gases after these had left the generating chamber. The former group turned their energies to the development of down-draft and double-zone arrangements, while the latter directed their efforts toward the production of up-draft producers and tar-handling apparatus. It has been the privilege of the writer to observe the operation of a number of plants of the latter type and to analyze the results of the operation of others.

Description of Apparatus

The plants belonging to the latter class are of two general types, suction and pressure, while the apparatus is essentially similar in each, varying principally in size and general arrangement. Fig. 1 shows a vertical section through the producer, scrubber and the water-sealed gas main, which is a characteristic arrangement for plants up to about 1000 hp. The pressure plant differs from the suction plant by the addition of a fan-type blower and a regulating holder. In the earlier plants the latter served as a large storage reservoir with capacity sufficient to keep the engines operating from 3 to 10 min. It was also thought that this large capacity tended to insure greater uniformity in the composition of the gas, so that the holders were placed in series with the engine and scrubbers. In more recent plants the size of the holder has been greatly reduced and in most cases floats on the line so that the gases do not pass through it. This change has been brought about partly because a large storage capacity is not required and in many places is undesirable. Also the mixing effect of the gases in the holder has proved a fallacy.

From Fig. 1 it will be noted that the producer *A* is of the water-sealed type, with a central blast *B* and superimposed vaporizer *C*. The gases pass direct from the producer to the scrubber *D*, which is provided with a vertical baffle *E*, from the scrubber to the water-sealed main *F*, and from this to the tar extractor *G*. The latter is of the centrifugal type and is illustrated in detail in Fig. 2.

Referring to Fig. 2, the gas enters at *A* and meets a stream of water at *B*. The mixture flows upon the rotating vanes *C* and is discharged into the stationary vanes *D*. The water and a portion of the tar are thrown out against the casing *E* and follow this around to the drain *F* which discharges into the seal pit *G*. The gas leaving the stationary vanes *D* reenters the rotating vanes *H* on the opposite side of the disk *I*. The gas here meets a stream of water from the nozzle *J* moving in the direction opposite to the gas which removes the remaining tar. The gas leaves at *K*. The extractors are usually designed to deliver the gas under a low pressure and are built in more than one stage for the larger powers.

A portion of the steam generated in the superimposed vaporizer *C*, Fig. 1, is used to saturate the blast. The amount supplied is indicated by the temperature shown by the thermometer *H*. The steam pressure on the vaporizer is maintained constant by the back-pressure valve *J*, while the air pressure on the main *K* is also constant. The valve *L* is therefore used to vary the amount of steam delivered to the blast. The butterfly valve *M* connects with the holder and regulates the amount of blast delivered to the producer. Changes in the position of this valve do not affect the relative proportions of air and steam. In more recent plants a thermostat located in the blast pipe operates a throttle valve in the steam line from the vaporizer in order to maintain a constant temperature of the blast.

The fuel is fed to the producer by the hand-operated centrifugal charging device *N*, which insures a very even distribution.

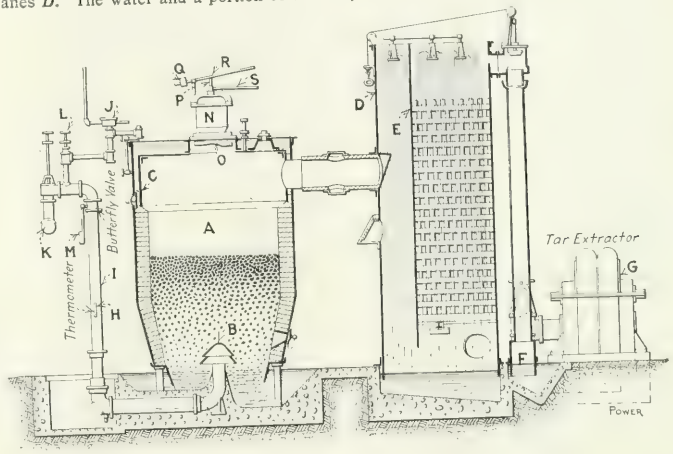


Fig. 1. Bituminous Producer, Scrubber and Tar Extractor

This consists of the hopper provided with a ribbed charging bell *O*, which is rigidly mounted on the shaft *P* and held against its seat by the counterweight *Q*. When the fuel is charged the bell is lowered by the arm *R* and at the same time rotated by the arm *S*. Both arms are hand operated. After the fuel is charged, the counterweight *Q* causes the bell *O* to seat. A sliding cover closes the top of the hopper which prevents the escape of gas while dropping a charge of fuel.

Thermal Efficiency

The efficiency depends to a certain extent upon the volatile matter. For fuels containing as high as 30 to 50 per cent. volatile matter, the thermal efficiency

*Excerpt from paper read at the spring meeting of the American Society of Mechanical Engineers.

based on the higher heating value of the gas is about 66 per cent., while the efficiency based on the effective heating value of the gas is ordinarily 5 per cent. lower than this, or 62.7 per cent. (exclusive of the power required to drive the tar extractor). Where the volatile matter does not exceed 20 per cent., the efficiency is somewhat higher.

The volume of gas generated per pound of coal depends upon the composition of the coal and the condition of the fuel bed. In a seven-day test on a producer plant using run-of-mine Pocahontas coal, the volume of the standard gas generated per pound of coal was approximately 71.5 cu.ft. For lignite the volume of standard gas varies between 36 and 40 cu.ft. per pound.

A large number of tests were made to determine the cleanliness of the gas delivered by the tar extractors, the results of which showed that the solid matter averaged about 0.0206 grain per cubic foot of standard gas. The determinations were made by drawing samples of the gas through three thicknesses of filter paper on which the solid matter was deposited. In most cases simultaneous samples were taken from the entering and exit sides of the extractor.

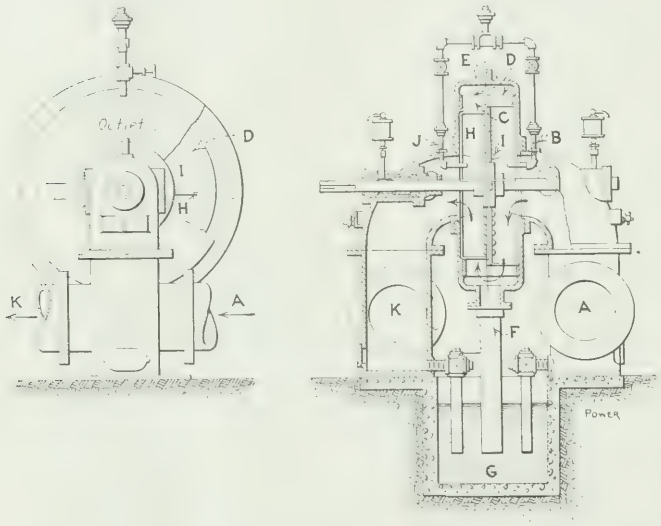


FIG. 2. TAR EXTRACTOR

HANDLING THE TAR

In the earlier plants difficulty was experienced by the tar accumulating in the scrubbers and pipe lines, causing frequent shutdowns. In almost every case this trouble was due to lack of experience on the part of the builders in designing these parts, and to the operators who failed to take proper precautions and profit by their first troubles.

In so far as the yield of tar is concerned, there are but three objections that can be urged against it:

1. Loss in efficiency of the plant due to the removal of a combustible constituent from the fuel.
2. The expenditure of power in driving the tar extractor.
3. Difficulties in the disposal of the tar.

The magnitude of these items is fairly well known. The loss in thermal efficiency varies from 12 per cent. for fuels containing from 15 to 20 per cent. volatile matter to 17 per cent. for fuels containing above or near 30 per cent. of volatile matter. The power required to drive the tar extractor depends upon the nature of the tar produced. With lignites, which produce a thin yellowish tar resembling very nearly a heavy oil, the power required is at least 25 per cent. less than the amount required for bituminous coals. For bituminous coals this power varies from 5 per cent. of the power of the plant in a plant of 100 b.hp. to about 3.5 per cent. for a plant of 1000 b.hp.

As to the difficulties in the disposal of the tar there is in some instances a ready market for the tar product; in other cases it can be burned under boilers.

The usual method of handling the tar is to place the extractor over a pit containing water into which the mixture of tar and water from the extractor is discharged. The pit is arranged so that the tar may be skimmed into a barrel or receiver. Where a receiver is used it is provided with an air-tight cover, and when filled the cover is put in place and either steam or air is forced in under pressure; this in turn forces it through piping to the point of disposal. Where the tar is thick and heavy, it is necessary to provide the receiver with a steam coil to keep the tar in a fluid condition.

PRODUCER PLANT COSTS

The cost of producer plants and of operating them are by no means fixed quantities, so that it is very difficult to give figures that are general and that can be safely applied to any and every case. Each plant requires individual consideration but the following applies to the general case:

The first cost depends upon

1. The service or load conditions and the magnitude of the load. These determine the necessity for duplicate or spare apparatus and the number of units into which the plant should be divided.
2. The design of the producer. With a given fuel one type of producer may gasify 50 per cent. more fuel than another type, or one type may be capable of continuous operation, while still another may require a light load during the period of the removal of ash.
3. The method of generating steam for the blast; that is, whether or not the producer generates its own steam supply or requires that this should be generated in separately fired boilers either fired direct or exhaust fired.
4. The characteristics of the fuel, including the percentage of ash. With low ash a plain water-sealed producer is satisfactory, but with ash above 12 or 15 per cent. a rotating table and cone bottom become desirable.
5. The scrubbing apparatus required which depends to a large extent upon the volatile matter in the coal.
6. The method of handling the coal and upon local conditions.

The operating costs are intimately connected with the first cost and depend upon

1. The character of the fuel, some fuels requiring more labor than others
2. The design of the producer.
3. The amount of ash.
4. The coal-handling machinery.
5. Facilities for handling the tar.
6. Supervision and local conditions.

FUTURE DEVELOPMENTS

The future for this type of plant is promising, as more economical results are now recognized as attainable, through improvements which tend to reduce the first cost of the plant and also the operating costs. These are an increase in the rate of gasification, a decrease in the power required to drive the cleaning apparatus, and utilization of waste heat. Increase in the rate of gasification has been made possible by a careful study of the effect of the distribution of the blast on the operation of the producer.

A number of years ago the writer demonstrated on a small anthracite producer in the mechanical-engineering

laboratory of the University of Illinois, that certain fuels could be gasified at rates as high as 40 lb. per square foot of fuel bed per hour without difficulty. Later while operating on lignite in Texas, which produced a very fine ash and caused considerable trouble in the ordinary central blast producer, the prime reason for the satisfactory gasification of one fuel at a very high rate of gasification and the failure in the gasification of another fuel at the same rate, was most clearly and forcibly demonstrated.

From this study and investigation it has become apparent that average fuels can be gasified at rates from 50 to 150 per cent. greater than the present rating of producers (9 to 10 lb. per square foot of fuel bed per hour), and with no increase in labor. This means a great reduction in the first cost of producer plants and also in the operating costs. Furthermore, the same principles produce the same results in large producers as in small producers, so that it is just as practicable to build a producer of large as of small diameter, while the labor per square foot of fuel bed required in the operation of the producer, the first cost, and operating costs are greatly reduced. A producer 9 ft. in diameter inside the lining, having an area of 63.6 sq.ft., requires less labor to operate than two producers 6 ft. in diameter (area 56.5 sq.ft.). It is, however, true that the gas from two smaller producers will probably be more uniform in quality than the gas from one large producer. The writer's experience would indicate that producers up to 15 ft. inside diameter are practical.

Utilization of the waste heat is an item that has received some attention in the past, but not as much as it warrants. As a rule, the average gas plant is extremely wasteful of heat. About 12 per cent. of the heat in the fuel is thrown away in the scrubber water, while about 60 per cent. is thrown away in the cooling water to the engine cylinders and in the exhaust.

Testing Internal Combustion Engines

By Everard Brown

The efficiency of an internal-combustion engine is the ratio of the heat converted into actual work to the total amount of heat received by the engine. In a general way, the difference between the heat of combustion and that in the exhaust is the measure of heat turned into work which may represent the degree of efficiency without expansion losses. An efficiency so determined, however, is of but little value and must, to a large extent, be based upon assumed values. The heat of combustion is always variable, due to leakage, radiation, absorption, mixture of the charge, etc.

It is practically impossible to record accurately these temperatures, for the changes are usually so rapid that no reliable observation can be made; also the computed temperatures are, at best, only approximate and can be calculated only from the known heat values of the fuel constituents. This would no doubt be fairly accurate if the inert gases of previous explosions could be excluded, but herein lies the difficulty.

Therefore, it devolved upon the indicator diagram to show what is going on within the engine cylinder so far as combustion and expansion are concerned and to point out the proper adjustment of the valves. While the diagram is being taken it is essential that the engine run steadily and with no misfires, so that the true indicated horsepower will be recorded. The speed should be recorded simultaneously, but the fuel-consumption test should cover a longer period—say, five or ten minutes—because it is rather difficult to accurately determine the amount consumed in the short time required to take an indicator diagram. Then, by calculating the total fuel consumption for one hour and dividing this by the average indicated power, as shown by the diagrams, the economic rating of the engine may be determined.

Instead of taking diagrams, the actual horsepower may be found by using a brake, in which case a continuous run under good conditions is necessary. One of the best ways to determine the power of a combustion engine is by connecting it to an electric generator. The amount of power in kilowatts can easily be found, and corrected for the loss of efficiency in the generator. This method also affords an easy means of determining how to develop more power and produce smoother operation. The element of speed must enter into any test, no matter how made, as it is important in establishing a rating. Much more elaborate tests can be made on engines of this type, but they are much finer and more delicate and require expert performance; such tests, however, hardly justify the trouble involved. For ordinary commercial purposes it has been found that the indicator diagram or the electric generator and, in some cases, the brake will answer all purposes. The horsepower so determined when compared with the actual amount of fuel consumed will give quite accurate data as to fuel economy, but it should always be borne in mind that before starting any test the cooling water should be allowed to flow until it attains a constant temperature.

By July 1 all the Canadian Pacific trains on the Field-Kamloops division will be hauled by oil-burning engines. This is the heaviest road in the Rockies and the use of oil will guard against forest fires.

CORRESPONDENCE

Troublesome Bearings

The bearings on one of our gas engines gave considerable trouble when the machine was new and it was very difficult to keep the engine running the first few months.

It is a center-crank tandem four-stroke-cycle machine having a belt wheel on one end of the crankshaft and a balance wheel of the same diameter on the other. The three bearings, one on either side of the crank disks and one between the spiral two-to-one gear and the belt wheel, are of two-piece construction. The lower halves are cast in the engine frame and the caps are set on at an angle of about 30 deg. with the horizontal. The only adjustment is to take off the caps and put in or take out liners.

These bearings seemed to contain very inferior babbitt and once they began to heat, it would tend to pull over and fill the oilways. We refitted the caps several times but this did not put back the babbitt that had been taken from the bottoms.

Early one Sunday morning we jacked up the shaft, made a runway of timbers for the wheels and rolled them out of the way. We could do little more, however, than scrape out the roughest places as it was impossible to roll the shaft in and out often enough to get a good fit in the limited time. We put things together again and found that conditions had improved somewhat, so an arbor was ordered the same size as the shaft, and another Sunday spent scraping and fitting the bearings. We got the engine together again by evening. It turned very stiff when barred over to the starting position, but after exhausting nearly all the air in the receiver it finally started.

We then discovered that our troubles were not over, for in scraping the bearings the shaft had been lowered so the teeth of the spiral two-to-one gear meshed too deeply, and it soon began to smoke. It meant either to lift out the shaft again, take out the layshaft and scrape the bearings until the gear meshed correctly, or file off the ends of the spiral teeth until they cleared. We chose the latter.

It was tedious but we did not have to take off much and about 10 p.m. were ready to start again.

Everything seemed in good shape except that there was a click about the crank. This we failed to locate that night, but later found it was caused by the tip end of the crank brass grazing the bottom of the crankcase. It was remedied by cutting the corner of the brass with a cold chisel. These bearings gave no further trouble for some time, but as we could not let the shaft any lower, as soon as they were out of true we had to rebabbitt them.

Earl Pagett.

Coffeyville, Kan.

Heating and Ventilation

Considered as power-plant problems. Layout and operation of systems and apparatus

Hot Water and Corrosion

Following are excerpts from a paper on "Hot Water Troubles" read by George C. Whipple before the American Water Works Association. The paper deals specifically with house heating, but that part of it discussing corrosion may interest engineers in charge of hot-water heating systems or hot-water service for house use.

According to the modern and generally accepted theory, corrosion of iron by water and formation of iron rust require first, presence of hydrogen ions in the water; second, presence of dissolved oxygen. Hydrogen ions are electrically charged atoms of hydrogen. All acids form them by dissociation. Whenever they are present in solution, that solution possesses acid properties. They attack metallic iron, which is dissolved in a ferrous condition. The oxygen dissolved in the water then oxidizes this ferrous iron and iron rust is formed. Under certain conditions this precipitates at once. Under others it apparently exists in a colloidal state; that is, an extremely finely divided state with its particles electrically charged, and precipitates only when this charge is neutralized. Very little is known about this phenomenon.

Iron naturally tends to dissolve in water as some hydrogen ions are always present. Pure water, therefore, by its dissociation acts as a weak acid. Even the purest distilled water splits up, or dissociates some of its molecules into hydrogen ions and hydroxyl ions. Distilled water therefore acts as an acid. Iron will be dissolved, and rust will form if oxygen is present. Whatever increases the hydrogen ions in water increases its corrosive power. Acids do this to a marked degree. Whatever decreases the hydrogen ions reduces the corrosive power. Alkalis do this. When alkalis are ionized, the hydroxyl ion is formed, and its electrical charge opposing that of the hydrogen ion neutralizes it.

A further conception of the phenomenon of iron rusting is that often referred to as "the electrolytic theory of corrosion." According to this a battery action takes place in the water and an electric current is set up between the metallic iron at one spot and some other metal or impurity at a neighboring spot. This action requires that the water be a conductor; it must contain electrically charged ions, and the higher the conductivity the greater the current. As a result the hydrogen ions give up their charge of electricity to the iron, which goes into solution, while gaseous hydrogen collects on the metal. As this gaseous hydrogen is a nonconductor, the iron, becoming covered with a film of it, is polarized, so that after a time the action ceases. Whatever removes the hydrogen from the metal depolarizes it and restores the action. Oxygen present in water does this, as it unites with the hydrogen to form water. Circulation of water containing oxygen, whether brought about by mechanical agitation or by thermal currents, also tends to remove the hydrogen. Oxygen therefore aids the corrosion of iron in two ways, by depolarizing it and by oxidizing the iron that goes into solution.

Presence of other metals also affects corrosion by increasing the difference of potential, and therefore the strength of the electric currents. This is termed "galvanic action." The metals act differently in regard to the direction of the currents between them and iron. Some cause the positive current to flow toward the iron and some retard it. The common metals and hydrogen are arranged in the following order of what is called the potential series: aluminum, manganese, zinc, iron, nickel, tin, lead, hydrogen, copper. Each tends to protect any other below it in the series from going into solution, but in doing so tends itself to dissolve. Thus zinc protects iron, but copper acts oppositely, and increases the solution of iron. Weston has shown recently by experiments on tin-lined lead pipe that the tin does not prevent the lead from dissolving. With two metals present, whatever increases the electrical conductivity of the water increases the corrosion of one metal or the other.

Corrosion and rusting require not only presence of the hydrogen ion, but presence of oxygen. It has been proved that where the hydrogen ion is present the rusting is proportionate to the concentration of the oxygen. The more oxygen, therefore, the greater the rusting. Generally speaking, hot water contains more than enough oxygen to oxidize the iron dissolved and probably the increased corrosion attending increased amounts of dissolved oxygen is due to its action as a depolarizer.

Surface waters used for public supplies are usually saturated with oxygen. Oxygen's solubility decreases as the temperature rises. Near the freezing point water dissolves about twice as much oxygen as at summer temperatures. The solubility decreases according to a regular curve and at the boiling point becomes nil.

The solubility of oxygen is also affected by pressure and increases directly with it. Water under two atmospheres pressure will hold twice as much oxygen as water under a pressure of one atmosphere. The solubility of oxygen in water at different temperatures and pressures is shown in the accompanying table.

SOLUBILITY OF DISSOLVED OXYGEN IN DISTILLED WATER AT DIFFERENT TEMPERATURES AND PRESSURES, PARTS PER MILLION

	Water Pressure, Lb. per Sq.In.					
	0	20	40	60	80	100
Temperature, Deg. F.	Pressure in Feet of Water					
	0	46.2	92.4	138.6	184.8	231.0
32.0	14.70	34.7	54.7	74.7	94.7	114.7
33.8	14.28	33.7	53.1	72.6	92.0	111.3
35.6	13.88	32.8	51.6	70.6	89.4	108.1
37.4	13.50	31.9	50.3	68.7	87.0	105.2
39.2	13.14	31.0	49.0	66.8	84.7	102.6
41.0	12.80	30.2	47.7	65.1	82.5	99.9
42.8	12.47	29.4	46.4	62.4	80.3	97.2
44.6	12.16	28.7	45.3	61.8	78.2	94.8
46.4	11.86	28.0	44.2	60.3	76.3	92.5
48.2	11.58	27.3	43.2	58.8	74.6	90.2
50.0	11.31	26.7	42.2	57.5	73.0	88.1
51.8	11.05	26.1	41.2	56.2	71.3	86.1
53.6	10.80	25.5	40.3	54.9	69.6	84.2
55.4	10.57	24.9	39.4	53.7	68.0	82.3
57.2	10.35	24.4	38.5	52.6	66.6	80.6
59.0	10.14	23.9	37.8	51.6	64.5	79.0
60.8	9.94	23.4	37.1	50.6	64.0	77.5
62.6	9.75	23.0	36.4	49.6	62.8	76.0
64.4	9.56	22.6	35.7	48.6	61.6	74.6
66.2	9.37	22.2	34.9	47.7	60.4	73.1
68.0	9.19	21.7	34.2	46.8	59.2	71.7
77.0	8.35	19.7	31.1	42.4	53.8	65.1
86.0	7.60	17.9	28.3	38.6	48.9	59.2
95.0	6.90	16.3	25.7	35.1	44.4	53.8
104.0	6.18	14.6	23.1	31.4	39.8	48.2
113.0	5.50	13.0	20.5	27.9	35.5	42.8
122.0	4.82	11.4	17.9	24.5	31.1	37.6
131.0	4.18	9.9	15.6	21.3	26.9	32.6
140.0	3.56	8.4	13.3	18.1	22.9	27.7
149.0	3.00	7.1	11.2	15.3	19.3	23.4
158.0	2.50	5.9	9.3	12.7	16.1	19.5
167.0	2.05	4.8	7.6	10.4	13.2	16.0
176.0	1.66	3.9	6.2	8.4	10.7	12.9
185.0	1.30	3.1	4.8	6.6	8.4	10.1
194.0	0.95	2.2	3.5	4.8	6.1	7.4
212.0	0					

When water saturated with oxygen is heated, the pressure remaining the same, oxygen is liberated, as is also the dissolved nitrogen. When a glass of cold water stands in a warm room, bubbles of air collect on the glass. For supersaturation to occur when water is under pressure the temperature must be raised considerably and the greater the pres-

sure the higher must the temperature be raised. For example, water just above the freezing point contains 14.5 parts per million of dissolved oxygen. If placed under 40 lb. pressure per square inch the temperature would have to be raised to 135 deg. F. for supersaturation to occur, and if the pressure were 100 lb. it would be necessary to raise the temperature to 170 deg. F. When heated above the saturation point, part of the air goes out of solution. This occurs to some extent in domestic hot-water systems. Rumbling of kitchen boilers is common where the tank system is used and the pressure is low. The liberated air ultimately escapes through the expansion pipe or the opened taps. Corrosion in feed-water heaters has been commonly noticed to increase with the temperature of the water up to a point somewhere between 170 and 190 deg. F., and above that to decrease.

Galvanized-iron or steel pipes are largely used in hot-water heating systems. They do not often corrode seriously, because the water is used over and over and the oxygen becomes used up.

The more rapidly water circulates through a hot-water system the greater is the pipe rusting, because the circulation prevents hydrogen accumulating on the metallic iron, that is, prevents polarization. This, with the mechanical removal of the oxidized iron, increases the corrosion.

Laboratory experiments made by various authorities have shown relatively little difference in the corrosion of wrought-iron and steel pipes. In tests made by immersing samples in strongly acid solutions, steel pipes sometimes have shown up better than wrought iron, and sometimes not as good. The laboratory data on this point are inconclusive. It seems to be common experience, and certainly the prevailing idea among engineers that wrought-iron pipes resist corrosion by water better than steel pipes. Whether this is due to inherent differences between the two metals, or to more frequent imperfections in the manufacture of steel cannot be determined readily from the data in hand. Homogeneity is important in preventing corrosion, and apparently steel pipe suffers more from lack of it than wrought-iron pipe. From practical experience, most engineers prefer the best grades of wrought iron; but probably the better grades of steel pipe are superior to the poorer grades of wrought iron.

Much depends upon the thoroughness of the galvanizing. Pure zinc affords the best protection. The coating should be sufficiently thick and so applied as to thoroughly cover the pipe. The old-fashioned dipping process gives best results.

If the above mentioned theories of corrosion are correct, the logical methods for preventing rusty hot water would be reducing the hydrogen ions in the water or increasing the hydroxyl ions, getting rid of the dissolved oxygen, reducing the temperature, pressure and circulation, and using good quality pipes selected with reference to the nature of the water. Practice can follow theory to a certain extent.

Doubtless the most effective way to avoid rusty hot water is to use brass or some metal other than iron or steel for the hot-water pipes and boilers. This increases the installation expense, but with very soft waters is advisable. Brass, if used, should be properly alloyed and well annealed; proper fittings also should be used.

If wrought-iron or steel pipes are used they should be of the best quality and well protected by galvanizing with pure zinc applied by dipping. Experience indicates that wrought-iron pipes of the best grade resist corrosion better than steel pipes, but so many exceptions have been found that this cannot be considered definitely established. Poor grades of both steel and iron pipe are to be avoided. Reforms are needed in the manufacture and methods of branding and selling smaller-sized pipe for use with hot water.

In domestic hot-water supplies it is not feasible to prevent water circulation in the pipes, nor is this desirable, as the circulating system has several distinct advantages. The hot-water pressure must depend chiefly upon existing conditions, but in designing a system where red-water troubles are feared, low pressure should be favored. Probably the temperature of the hot-water supply often is maintained higher than necessary for domestic uses, and then red water could be materially reduced if excessive heating were prevented by using an automatic control.

Neither is it feasible nor desirable to remove the dissolved oxygen from a public water supply, except for boiler waters, when the results are said to be beneficial. Nothing hinders its being done for hot-water installations in large buildings, as apartments, hotels and office buildings, where large numbers of taps are supplied from a common source. By first heating the water to, say, 175 to 195 deg. F., and then raising it to an open elevated tank, much of the dissolved oxygen and carbonic acid as well would be liberated and its corrosive power materially diminished. More complete removal might be obtained by using a closed storage tank with a partial vacuum. Whether this would produce better results than a regulated low temperature is yet to be determined.

Most effective in preventing rusty hot water, next to avoiding iron and steel pipe, is to reduce the hydrogen ions in the hot water, or, what is equivalent, increase the hydroxyl ions. This practically means that the public water supply should not be too soft. Experience seems to indicate that the alkalinity should be at least 10 or 15 parts per million. The higher the alkalinity the less the chance of rusty hot water.

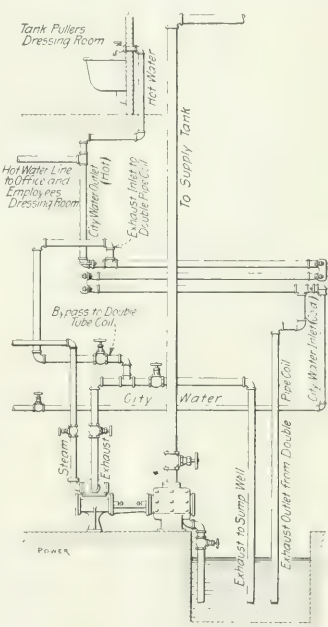
Public water supplies high in organic matter and low in alkalinity may be advantageously hardened by adding a small quantity of lime, say 10 or 15 parts per million. This practice has long been common in England.

With hard waters, where the hardness is due to carbonates, practically no precautions need be taken, as the hardness itself seems to be sufficient to prevent rusty water troubles.

LETTERS

Hot Water Kink

I once worked in a plant where the management could not see its way clear to provide hot water for the help, and so the man in charge had to get up something to stop the kicking. We rigged up a three-pipe section of a double-tube



ARRANGEMENT OF PIPING

ammonia condenser so that the exhaust steam from the sump pump could be passed through it. The city water was passed through the inside pipe in a direction opposite to the steam.

No pressure can be built up in the coil as the exhaust steam cannot heat the water enough for that. If there is any call to shut off the steam from the coil, this can be readily done and the steam exhausted into the sump. If the water should get too hot, the two valves

can be operated so that half of the steam could be passed directly into the sump and the balance through the coil.

EDGAR G. SCHINDLER.

Roxbury, Mass.

Gas Fired Heating Boilers

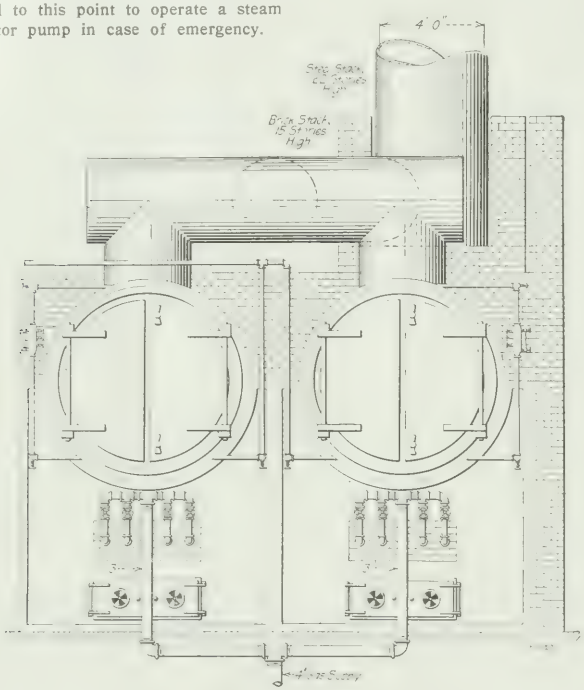
In a 14-story office building there are two 54-in. by 16-ft. fire-tube boilers used for heating. They carry 40 lb. steam pressure and steam is furnished to the heating system at 5 lb. pressure by a reducing valve. The safety valves are set at 100 lb. and the pressure can be raised to this point to operate a steam elevator pump in case of emergency.

Each boiler is set up and equipped identically the same, and each is free from scale or soot. Yet boiler No. 2, next the wall, uses 30 per cent. more gas than the other under the same conditions. Only one is used at a time. To do the same work No. 1 boiler requires two burners and for No. 2 three burners must be operated.

The sketch will give some idea of the layout. Will someone explain the reason for this?

L. M. JOHNSON.

Glenfield, Penn.



ARRANGEMENT OF HEATING BOILERS

The boilers are exactly alike and are set up and piped alike. They are fired with natural gas by means of four Kirkwood gas burners under each boiler. The gas is supplied through a 4-in. pipe with 3-in. branches to each boiler leading to a set of burners attached to a 2-in. manifold by 1¼-in. pipes. Each boiler has a checkerwork baffle wall just in front of the bridgewall. Each baffle wall is laid up in the same way and at the same distance from the burners.

The smoke uptakes rise from the front of each boiler and connect to a common breeching, from the center of which the flue runs to the back of the boilers, where with a 45-deg. turn it enters the stack which rises 22 stories above the boiler room to the top of the adjoining building. The damper is in the horizontal flue.

Siphon on Return

The chief requirement of this system is a supply of water under pressure (about 60 lb. in this case) to operate the water siphon which is used instead of a pump, to create a vacuum and remove the condensation; this it does very satisfactorily.

It has been in operation for two winters and has given very little trouble. The system heats a pattern shop with two 220-ft. overhead coils of 1¼-in. pipe, one wall coil of 210 ft. of 1¼-in. pipe, one glue pot, a lumber-drying room having 396 ft. of 2-in. pipe laid on the floor, a pipe fitter's shop with two wall coils containing 270 ft. of 1¼-in. pipe each, a repair shop having two wall coils with 180 ft. of 1¼-in. pipe each and one with 80 ft. of 1¼-in. pipe; a water heater for furnishing hot water to a bath and wash room, one radiator in an office and three in a small laboratory building.

The underground mains were laid in a wooden trough packed with mineral wool and covered with corrugated metal arches as shown in the sketch.

The siphon was made of ordinary pipe fittings. The discharge is connected to the sewer, as with no separator on the line, the water is slightly mixed with oil.

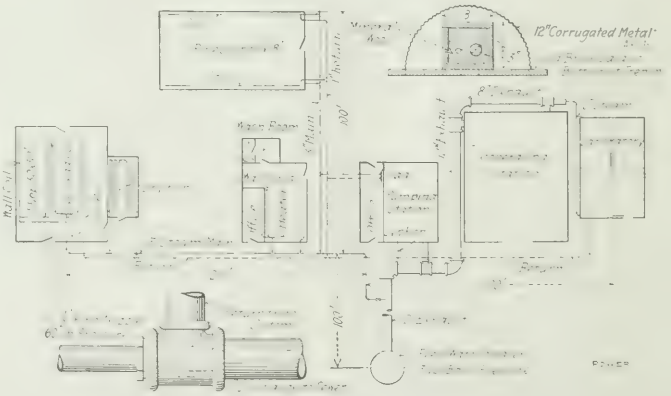
The buildings are quite a distance from each other, as shown in the sketch. The system kept all the buildings heated to about 70 deg. F. in the coldest weather.

E. G. GERBER.

Middletown, Ohio.

"Supposing," said the examiner, "you had renewed the manhole gaskets, had tightened up the nuts on the manhole dogs and had got 125 lb. of steam, what would you do if a dog came off and the handhole plate fell in?"

"I'd go in after it," answered the candidate. "Any plate that could fall in against a pressure of 125 lb. would be worth going after."



LAYOUT OF SYSTEM ON WHICH SIPHON WAS USED

Issued Weekly by the
Hill Publishing Company
JOHN A. HILL, Pres. ROB'T MCKEAN, Sec'y.
505 Pearl Street, New York.

Monadnock Bldg., Chicago.
6 Bouverie Street, London, E. C.
Unter den Linden 71—Berlin, N. W. 7.

FRED R. LOW, Editor.

Correspondence suitable for the columns of POWER solicited and paid for. Name and address of correspondents must be given—not necessarily for publication

Subscription price $2 per year, in advance, to any post office in the United States or the possessions of the United States and Mexico. $3 to Canada. $5 to any other foreign country.

Pay no money to solicitors or agents unless they can show letters of authorization from this office.

Subscribers in Great Britain, Europe and the British Colonies in the Eastern Hemisphere may send their subscriptions to the London Office. Price 21 Shillings.

Entered as second class matter, December 20, 1910, at the post office at New York, New York, under the Act of March 3, 1879.

Cable address, "POWPUB," N. Y.
Business Telegraph Code.

CIRCULATION STATEMENT

Of this issue 29,500 copies are printed.

None sent free regularly, no returns from news companies, no back numbers. Figures are live, net circulation.

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POWER

Water in the Low-Pressure Cylinder

In another column is told very lucidly how the low-pressure cylinder of a compound engine may be wrecked by water, notwithstanding the impossibility of pulling it over from the condenser. Some years since POWER recorded a serious accident of this kind where the engine had been running light for a considerable time and the end of the drip pipe from the receiver was submerged in a drain. The arrangement of the piping shown in the illustration accompanying the present article is not above criticism, but the drawing was made from an existing plant and there are many others to be found which are no better.

It is a deplorable fact that there are engines in daily operation supplied with steam through long lines of piping in which there is no separator. There are engines running without relief valves on the cylinder. To relieve a cylinder of a large dose of water in the limited time available would require a relief valve of prodigious proportions, but ordinary relief valves do prevent damage when the water comes in limited quantities and might furnish an admonition against a gathering accumulation. The boilers should be kept clean and watched for signs of priming.

There are feed-water regulators to be had which will prevent the carrying of too high a water line and a large separator near the engine will pay for itself in sustaining the initial pressure and the reduction of the baleful effect of water in the cylinder aside from its liability to cause a wreck. It goes without saying that the receiver trap should be a thoroughly reliable one and should be watched with vigilance.

A trap which will discharge from a vacuous space into the atmosphere may be used or it might be possible to discharge it to the condenser if provision were made for free discharge when the condenser is not in operation.

Engineers who are sensible of liability to accident from the lack of these precautionary appliances or from faulty arrangement of the receiver and piping should call the attention of those in authority to the existing conditions, explain just why they are dangerous and put in a requisition for the needed changes and appliances, so that they may be upon record as having recommended means of prevention if an accident does occur.

Standard Flanges

There is war between the societies and the manufacturers of flanges and flanged fittings.

In the fall of 1911 a joint committee of the National Association of Master Steam and Hot Water Fitters and the American Society of Mechanical Engineers recommended a schedule of standard-weight and extra-heavy flanged fittings and flanges, tabulated in our issue of Mar. 19 of this year. It has since been approved and recommended by the American Society of Heating and Ventilating Engineers and by the Bureau of Standards of the United States Government.

But the manufacturers of flanges and flanged fittings will have none of it. They claim that it was sprung upon them without consultation and adequate discussion, and, through a committee, have issued an injunction or warning to engineers not to specify or order fittings by the so called 1912 Standard. They say that this standard has not been accepted as final by the manufacturers and will not be accepted until certain necessary revisions have been made, "to meet the practical requirements of all concerned."

The committees claim that the coöperation of the manufacturers was sought, that every opportunity was offered to them to discuss the changes necessary to bring about uniform as well as safe practice, both before the report was submitted and while it was before the several societies for discussion, but that the attitude of the manufacturers was such as to discourage any change, and that

it is only after the schedule has been adopted and promulgated and they are receiving specifications under it, that the manufacturers have shown any disposition to take the matter seriously.

The desirability of a uniform standard is undeniable. One should be able to send to a dealer and get a flanged fitting which will fit into a job without having to look up the history of that which is to be displaced and the representative of the same manufacturer or have one made to order. One should not have to make a separate set of drawings and calculations for the same job, according as one or another manufacturer is to furnish the flanges and flanged fittings. A 10-inch tee should be of the same length and thickness and have the same bolt circle and number of bolts in whatever shop it may have been made. The desirability of a standard is too obvious and imperative to discuss, and its importance far transcends any consideration of inconvenience and expense which the manufacturers may be put to in bringing their patterns and catalogs into agreement. If a standard schedule, approved by those who specify and buy flanges and flanged fittings, be proposed and adopted, those manufacturers who accept this schedule and adapt their products to it will have an advantage which the others cannot afford to forego.

There has been no such uniform standard. With the exception of five manufacturers who have adopted what is known as the Crane Standard, each producer was a law unto himself. These five manufacturers think that their standard is good enough, better in fact than that of the societies, and that if uniformity is the consideration, a standard upon which so many are already working should have been adopted instead of something which will impose trouble and expense upon everybody. This schedule was, of course, before the joint committee when it made up its schedule and it will be interesting to examine the departures from it which the committee has recommended, which will be done in an early issue of POWER.

In the meantime the societies stand upon the schedule recommended by their committees and the manufacturers are trying to discourage engineers from using this schedule in their specifications. If they can point out faults in the schedule at this late day, they should do so and the schedule should be revised to correct any real defects, but some one schedule—the best schedule—should be universally adopted. Uniformity is of more importance than anybody's individual preference or interest.

Foolish Central Station Arguments

The intelligence and reasoning ability of engineers seem to be questioned, judging from some of the central-station literature addressed to them.

It assumes a beneficent interest in the welfare of the isolated-plant engineer, and points out the way to avoid the heat of the engine room, the dust and dirt accompanying the handling of coal and ashes and the petty details of plant operation.

No real engineer would even think of retiring his plant in favor of a central station just because it is hot—he would put in a ventilating fan. A more flimsy excuse for putting productive machinery out of commission is inconceivable. Every isolated plant represents an investment of thousands of dollars. If it is properly operated the cost of producing a kilowatt-hour at the switchboard should be much less, if the plant is of any considerable size and is credited with the steam used for heating, than that at which a central station can produce, distribute and collect for the same electrical output.

How, then, can an engineer, having the interest of his employer in mind, advise the substitution of central-station service for the isolated plant?

It is an easy way of making the engine room the coolest part of the building, but what an inducement to offer to a progressive engineer!

Of what moment are the petty details as compared to the brain part of the job? Doubtless shutting down the power plant will eliminate all details relating to isolated-plant power generation and the engineer *will* have more time to attend to the rest of his job (if there is anything worth while left). How can adapting central-station service resulting in a greater yearly cost, make an engineer more valuable or his job bigger?

Such ideas are advanced for a purpose, but it would be as convincing to suggest that battles may be won by ordering the soldiers to retreat because of the danger, noise and dust, as to attempt to persuade an engineer that his best interests will be served by shutting down his plant to increase his comfort or save himself work.

Analyzing the Exhaust Gases

For many years boilers were operated by rule-of-thumb methods; if the fire burned brightly and looked good to the experienced fireman the boiler was apparently being handled efficiently. Later, however, more scientific methods came into use. Engineers began to realize that there was such a thing as excess air, also that furnaces must be arranged so as to aid in more perfect combustion of the gases; each of these having an important bearing upon the efficiency of the boiler. Naturally the index to these conditions was the composition of the flue gases, and special apparatus was evolved for analyzing them. At first this was more or less of an experimental nature, but its use has now become so general that a boiler room is looked upon as incomplete unless equipped with means for analyzing the flue gases.

The operation of the gas engine seems about to undergo a similar change. Ordinarily the experienced ear of the operator, or indications of the switchboard instruments (if the engine drives a generator), are depended upon in regulating the mixture. This introduces a personal factor which, at best, is usually undesirable when unsupported by any other check. The natural place to look for such a check would be in the composition of the exhaust gases. Their analysis would show not only whether the engine was running on the proper mixture but would prove a valuable aid to making adjustments of the mixer. It also furnishes a means for accurately determining the heat wasted in the exhaust and thus permits calculating very closely the thermal efficiency of the engine.

Although certain steps have been taken along this line they have been, for the greater part, of a laboratory nature. Such work is very often necessary before making practical applications, but we venture to predict that the time is not far off when an Orsat apparatus will be just as much a part of the gas-engine equipment as it now is of the boiler room.

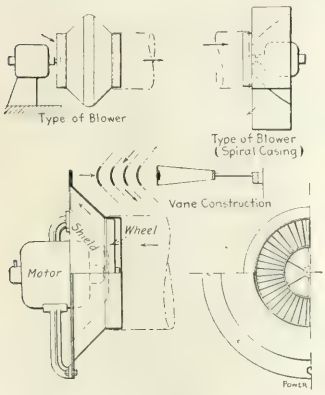
Readers with Something to Say

A letter good enough to print will be paid for. Ideas, not mere words, wanted

Axial Flow Turbine Fan

The wheel illustrated is 9½ in. in diameter and has 48 vanes tapered toward the center and curved in cross-section in stream-line form. The shield must be designed in spaced relation to the wheel, to prevent the center of the wheel working overloaded and to bring the center air up to the velocity of the gyration circle. This shield may be adjusted to or from the wheel to vary the load. No casing is required for operating it as an exhauster connected to piping.

In starting the wheel, a rarefaction is caused by the moving air on the face of the shield, which tends to draw air through the wheel axially. The resultant



DETAILS OF TURBINE FAN

of this and the centrifugal force gives the air a spiral whirl on leaving the wheel, with the greatest vacuum at the center.

The ultimate velocity of the air from the whole face of the wheel would come on the principal radius of gyration, or 0.7 of the wheel radius, but in operation a greater velocity is found, showing the air travels faster than the wheel. The blast area seems to be

$$\frac{\text{Area of face of wheel}}{3}$$

which is a larger area than that of centrifugal multivane fans of the same diameter. The power consumption compares well with other types of fans.

Features peculiar to this fan are that the inlet opening is the full diameter of the wheel; that the air enters normally to the plane of the blades, thus eliminating turns and the tendency to "skid" along the blade and pile up on the far side; that the entry edge of the blades may be curved forward to follow the stream line formation and eliminate impact, and that the wheel is lighter and better balanced for high speeds than others.

For the same diameter and speed this wheel gives half the pressure of a multivane centrifugal fan. If the wheel perimeter travel is, say, 2585 ft. per minute, then a point at the radius of gyration from the center will travel 0.707 of 2585, or 1828 ft. per minute; 1828 and 2585 ft. per minute are respectively the velocities of air giving ⅛ oz. and ¼ oz. pressures. Therefore, for the same pressures this fan would revolve 1.43 times faster than the multivane centrifugal fan (the power consumption is the same for a given volume) and is thus better adapted for turbine drive. In ventilating work a slow-speed fan for low pressures could be replaced with this smaller fan at a higher speed, giving the same volume at the same pressure and power consumption.

As a winnowing machine, shown in the illustration, the wheat or other material is thrown from the bowl in a whirl, the heavy product falling near the machine while the lighter is blown off; the operation reminds me of the old Spanish arrastra which was used by the Mexicans in mining.

I would welcome criticism from interested readers on this type of fan.

C. O. BRETHERICK.

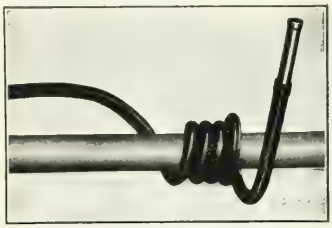
Seattle, Wash.

A Strange Accident

The illustration shows a 1 11/16-in. countershaft, 11 ft. long, with shrunk collars on one end, coiled about a 4 7/16-in. main shaft. The peculiar mishap came from a sudden application of load to the countershaft, which caused the driving belt from the main shaft to slip from the pulley and wrap the shaft. As the belt wound up, it dragged one end of the countershaft with its hanger over, and all became firmly entangled in the arms of a large pulley on the main shaft. The hanger on the other end broke, and the end thus freed struck a girder overhead which held it until the countershaft was coiled tightly on the main shaft. When the coil had wound up enough to release itself from the girder, the revolving end tore up the floor planking within its range and created considerable noise and commotion.

To resume running the plant, it was necessary to saw off the projecting ends of the coiled shaft, and at the first shutdown the coil itself was removed.

To obtain the illustration the severed ends were wired in position and a wood roll of the same diameter as the main shaft was inserted to represent it.



SMALL SHAFT COILED AROUND LARGER ONE

The main shaft was turning at 270 r.p.m. so that the four convolutions were produced almost instantly, and anyone who has attempted to coil a small wire spring can appreciate the power necessary to produce the result above described.

H. E. OSGOOD.

Wilmington, Del

Losses in Uncovered Steam Pipes

We have 4826 lineal feet of steam pipe from 1 to 4 in. inside diameter in operation at the present time, the outside surface of which is exposed to the atmosphere.

Up to the present it has not been advisable to insulate many of these lines, due to changes in the manner of operation, which caused continual changing of lines or installing new ones. Although the loss due to condensation, etc., has been heavy, we believe it has been justified inasmuch as the covering would have been broken up and spoiled by handling from one line to another.

Our main lines (10 in. and 6 in.) are all insulated as well as some of the permanent smaller lines, and as the balance of our steam lines are now permanently located, and tight, they should be insulated.

According to publications of the American Society of Mechanical Engineers, the rate of radiation and condensation is 2.706 B.t.u. per square foot of radiat-

ing surface per hour per degree average difference of temperature inside and outside of the pipe.

Our average steam pressure is 100 lb. per square inch, or 115 lb. absolute; its corresponding temperature is 338.1 deg. F., its total heat 1188.8 B.t.u., its latent heat 879.8 B.t.u.

Based on an average atmospheric temperature for the year of 60 deg. F., our average difference is 278.1 deg. F. Taking the constant of radiation 2.703 to one decimal place, which is sufficient, we have

$$2.7\ B.t.u. \times 278.1\ deg.\ F. = 750.87\ B.t.u.$$

per square foot per hour in heat radiated or lost. This 4826 lineal feet of bare pipe has a radiating surface of 3626.1 sq.ft.

$$3626.1 \times 750 = 2{,}719{,}575\ B.t.u.$$

per hour. The calorific value of our coal is 10,816.85 B.t.u. per pound

$$\frac{2{,}719{,}575}{10{,}816.85} = 251.4\ lb.$$

of coal lost per hour, or

$$251.4 \times 24 = 6033.6\ lb.$$

per day = three tons, and three tons at $1.65 will be $4.95 per day, or $1806.75 per year.

This is our direct loss by radiation based on coal as delivered to the coal trestle. Our total loss, due to these uncovered lines, in steam condensed, which represents coal, labor, etc., necessary to generate and maintain steam at an average of 100 lb. pressure is as follows:

By the radiation of heat units from the exposed surface of the pipes, steam is condensed, due to the loss of its latent heat. As the latent heat of steam at 100 lb. gage is 879.8 B.t.u. per pound and we are radiating 750 B.t.u. per square foot of exposed surface per hour,

$$\frac{750}{879} = 0.856\ lb.$$

of steam per square foot of exposed surface per hour is condensed, and as this steam has done no work it is an absolute loss.

$$0.856\ lb. \times 3626.1\ sq.ft. = 3103.9\ lb.$$

of steam lost per hour. Our cost of steam is 11.63c. per 1000 lb.

$$3103.9\ lb. \times 0.1163 = 36.1\ cents$$

per hour, or $8.66 per day; $8.66 × 365 = $3160.90 per year lost due to condensation in these lines. This is equivalent to 90 boiler horsepower, or 11.7 per cent. of that developed.

Based on a sectional pipe covering of 70 per cent. efficiency, this loss can be reduced to about $950 per year, and possibly more, by installing a better grade of covering.

After giving up its latent heat, the condensation still has a heat value of 309 B.t.u. and is also free of most scale-forming substances. By installing suitable receivers and traps, a large amount of this water may be returned to the boilers at a fairly high temperature.

This system, with our pipes well insulated, should show a saving of 90 per cent. of the present loss, or about $2800 per year.

J. L. KEZER.

Bradford, Penn.

Draining Steam Pipes

So many accidents to steam engines can be traced directly to water in the steam pipes that their frequency should result in the adoption of safeguards by all engineers and steam users, but each one apparently thinks that such an accident could not happen in his plant, simply because it never has.

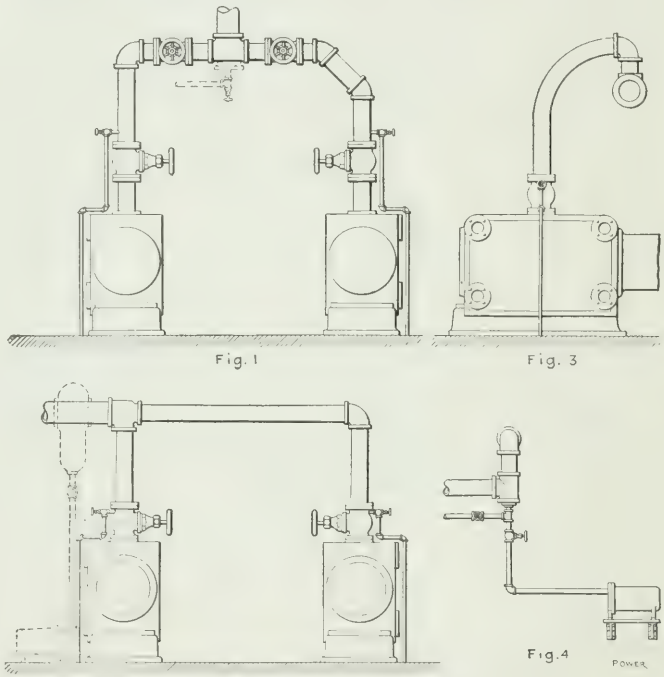
Fig. 1 illustrates the pipe by which a double Corliss engine is supplied with steam. The main pipe from the boilers is brought down through the ceiling and fitted with a reducing tee, forming a branch to the right and left, as shown by the full lines. Each branch has a valve to shut off the supply if only one cylinder is used. Two 45-deg. ells are used in the right-hand connection, instead of one 90-deg. ell, to clear an I-beam which supports the ceiling at this point.

If this engine were to be shut down for several days and steam required in other departments of the shop, these two valves should be closed, but if this is done with the present arrangement, the pipe will fill with water and it would not be safe to open either valve, because water-hammer might split the pipe or crack the fittings.

If a reducing cross had been used at the point indicated by dotted lines, the small drip valve could be safely opened, because the outlet is too small to cause rapid circulation in a cold pipe.

In everyday service the small drip valves, shown above the throttle valves, are opened before the engine is started, and then closed. This disposes of water that has collected since the engine was shut down, but does not carry away any coming over from the boilers while the engine is running. The cross mentioned forms a good drip pocket and if the small pipe is connected to a reliable trap, it will keep the line practically clear. Relief valves on cylinders are valuable, but it is better to remove the water before it goes into the cylinders.

Fig. 2 illustrates a very poor form of pipe connection for a double engine. Nearly all water in the main pipe will go into the first cylinder; this is dangerous. If a good separator had been installed, as shown by the dotted lines,



STEAM PIPING SHOWING DRAIN LINES

and the drip pipe had a good trap, only dry steam could go to the engine.

Fig. 3 illustrates a good device used in a plant where the boilers prime badly, sending large quantities of water into the main steam pipe. As steam for this engine is taken from the top of this pipe, little will go to the engine unless the main pipe is nearly full.

Fig. 4 shows the end of this pipe and a tee connected to form an outlet at the top to supply steam for another engine. The bottom of the tee forms a good drip pocket and the pipe from it discharges into a trap. A tee in this pipe looks to the left, the outlet thus provided discharging into the boilers below the water line. This is used most of the time, and is preferred because the hot water is saved.

W. H. WAKEMAN.

New Haven, Conn.

Water Level Fluctuates

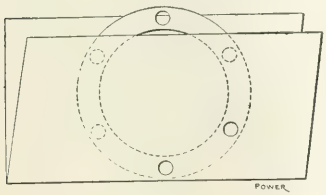
Our three-drum type Babcock & Wilcox boilers each have one water column and gage-glass connected to one of the end drums. The water will at times suddenly rise and at other times fall considerably in the glass. I believe it is due to local circulation within some of the tubes and one header. Will some interested reader experienced with this type of boiler fully explain the cause?

B. H. CHESTER.

New York City.

Inserting and Removing Gaskets

When inserting a gasket between flanges that cannot be separated to any great distance, it is often troublesome to get the gasket into position. To overcome this, fold a piece of stiff paper as shown in the sketch. The paper and gasket can



GASKET READY FOR INSERTION IN FLANGE

easily be slipped in between the flanges, and after one or two bolts are put in place the paper can be taken out.

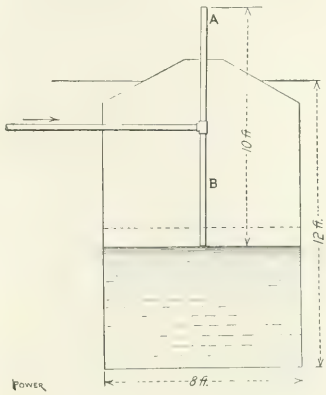
To remove an old gasket when the flanges can be separated but very little is usually difficult unless a length of pipe is taken out. A simple way is to drive a cold chisel in the lower side of the joint sufficiently to loosen the flanges, and then run an old saw through the joint, sawing out the gasket. After sawing partly through, drive the chisel in the top of the joint to keep the flanges from pinching the saw and saw out the remainder of the gasket.

EDWARD L. JOHNSON.

Brooklyn, N. Y.

Why This Peculiar Exhaust?

The exhaust pipe from our engine is run into a well 12 ft. deep and 8 ft. in diameter; the pipe is connected as shown in the illustration. When the water in the well rises to the height indicated by the dotted lines, no steam is exhausted



EXHAUST PIPE LED INTO WELL

from *A*, which is open to the atmosphere, but when the water level is just below the end of the length *B*, both steam and water are exhausted from *A*. The top of the well is always open to the atmosphere. What causes this peculiar action?

A. O. FISHER.

Elkhart, Ind.

Correcting a Centrifugal Pump Trouble

Recently I was consulted regarding a 4-in. motor-driven volute pump running with 4-ft. lift and 35-ft. discharge head that refused to raise water.

The pump and motor were on a subbase and to erect required only connecting the pipes and wiring the motor. A machinist did this and packed the shaft bearings. The pump would work well about 20 min. then gradually lose its water, although the supply was constant. The machinist and millwright tried for several weeks to fix it but unsuccessfully. During this time the superintendent wrote to the makers who stated that the pump was tested in the usual manner and found satisfactory before shipment.

First I examined the strainer and foot valve and found them clear, then I pulled out the packing and discovered the trouble. The water-seal glands were sent packed in a box with the other trimmings, and in packing, the machinist cut off a long piece of coil packing and wound it around the shaft and drove it in until the stuffing-box was full. As it got hot when running, he eased up on the gland nuts, letting air leak in and gradually destroy the vacuum. I found the water-seal spools hanging up in the machine shop. The machinist stated that he could find no place to use them. It took 40 min. to get the pump properly packed and working to full capacity with no further trouble.

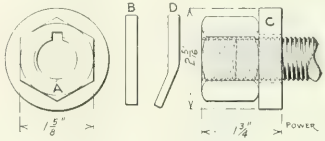
J. C. HAWKINS.

Hyattsville, Md.

Stud Extractor

The illustration shows a stud extractor I made for pulling 1-in. studs from pistons. The studs had been in use over 10 years and were screwed in so tightly and closely that a socket wrench was the only tool possible to use.

The keyway in the nut *A* was cut just deep enough so that when the cutting key *B* was driven it would only cut the threads as far as the base of the nut. Screwing the nut on the stud a distance of five threads and driving the key give sufficient holding power to allow two men to back off the stud with a 36-in. pipe wrench. After the stud is withdrawn the



STUD EXTRACTOR

nut is placed in a vise so that the collar *C* rests on the jaws, and the key is then driven out with the driver *D*.

The extractor nut should be tapped deeply to allow for shrinkage, after which it should be case-hardened. The collar should also be case-hardened and the cutting key and driver made of tool steel. I made the collar large enough to fit the counterbore of the follower plate.

DAVID G. YOUNG.

Cliffside, N. J.

What Corroded the Pipe?

A 1-in. wrought-iron gas pipe screwed in the top of a 4-in. cast-iron main was badly eaten away on one side only. Several holes were present, and around them along the side of the pipe was a large area that had materially wasted away; the interior was unharmed.

This pipe was laid only three years ago in a paved street. No other pipes run adjacent to it, and the street-railway lines and power house are a block away. Was electrolysis the cause?

J. E. B. PHELPS.

Sarnia, Ont.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

The College Graduate and Practical Experience

The editorial "The Technical Graduate and the Power Plant," in the May 14 issue, and the foreword "To the College Grad," in the May 28 issue, are decidedly interesting to one who has recently gone through that part of the mill they refer to.

Some graduates feel it beneath their dignity to get down to manual labor as a starter after graduation, and when it comes to wiping up grease and getting under a machine to repair it, with the oil running down their neck, they would rather be excused; these men apparently have a yellow streak in their engineering makeup and like the "quitter" may "get by," but not as well as the man who is not afraid to get dirty.

A couple of years or more in a power plant as water tender, oiler, watch engineer, etc., going through the different minor positions, may be good experience, as noted in the articles referred to, but two years in a large industrial establishment brings one in contact with more and varied classes of men as well as positions than in a power house; after which a short while in a power house will be excellent final training, if the industrial establishment was one manufacturing power-plant apparatus.

A technical graduate can get much out of two years' practical training with a large industrial establishment, like the General Electric Co., for example. Let him start in the machine shop. Here he will learn how to run the various machine tools, and realize the different environment here from that in the college machine shop. Work must be got out because a promise has been made on this or that requisition. He will work, for example, with the day workers in the tool room or repair shop or he may spend some time with the piece workers who are pressed for time. In each part of the shop a different kind of human nature predominates; a study of this alone is well worth the experience. Finally, one may take charge of a small part of the work and here comes that valuable training in diplomacy of how to handle men.

Suppose he has had enough of the shop and now goes through the various tests of steam turbines, air compressors, gas engines, etc., if he be a mechanical man; motors, generators, transformers, meters, instruments, etc., if he be an electrical man. In each place he again applies his theoretical knowledge practically, and learns the short cuts the professional tester uses. Here a different class of men is encountered and points on human nature again are acquired that can be gained in no other way, besides that valuable experience of how to handle the apparatus he expects to operate, design, manufacture or sell, some day in the future.

Then comes the drafting office, and engineering office experience and perhaps some cost, or production department work, if he be inclined that way.

To cover all of it thoroughly would require more than two years, but at the end of that time, he should know definitely what branch he wants to follow. Then, if power-plant work be his goal, let him spend a short while in a power plant and he should soon master the details of his chosen work. If manufacturing, designing or selling were his choice, he could follow these up similarly in a practical way.

Some may say this is a long time to spend preparing for the engineering profession. Perhaps it is, but compare a physician—how long he studies, and how much time he spends at the hospital and then building up a reputation. Our profession has grown so in size that it cannot be mastered as easily as formerly.

JULIUS G. BERGER.

West Lynn, Mass.

Why Clinker Forms

The peculiar difficulty cited by H. B. McDowell, in his inquiry in the May 7 issue, is not as easily explained or corrected as might at first appear.

The clinker formation is not due to the fuel, because two boilers, one with a special furnace and one with a standard furnace, are exempt, and the second boiler with the special furnace only evidences trouble in a particular part of its grate.

The difficulty might be due to the tubes comprising the water bars, which at the particular part of the furnace where clinkers form may be found to be dirty inside, and thus permit the fire to be hotter at that point than it would be if the heat was absorbed by a perfect circulation of water.

Another solution may be found in the draft. Ordinarily, the boiler most distant from the stack would have the poorest draft, and the boiler referred to is farthest from the stack. It is possible, however, that the individual dampers, if such exist, may be so adjusted that this particular furnace has the most intense draft at the particular point where the clinkers exist, and it may be found to produce most intense heat at that point and thus cause the formation of clinker.

There is a positive reason for this particular formation, but without complete data on the entire plant, or draft in this particular furnace in comparison with the others, and the degree of cleanliness maintained, it is hard to suggest any conclusive reason for the existence of the trouble.

I trust we shall hear further from Mr. McDowell on this matter, and particularly so when he finds the reason for his difficulty. I would experiment with the conditions of draft of the three boilers in a comparative way, and also take measures to alter the thickness of the fuel bed on this particular boiler, and carefully note any effect that might be produced. If such investigations do not develop a solution, the cleanliness of the water bars should be next given attention.

CHARLES H. PARSON.

New York City.

My experience leads to the belief that Mr. McDowell's clinker trouble is due to the following causes:

The temperature of the fire is greater on the side which formed the clinker; this is caused by more hot air being furnished and more combustible gases being distilled and burned. This condition could exist due to some peculiarity of furnace, gas passages and breeching which produce eddy currents.

CECIL R. COILE.

Fort Morgan, Ala.

Mr. McDowell's trouble is undoubtedly due to poor draft. With the Hawley down-draft system particular attention should be given the draft as it must be strong to produce good results. The chimney draft, if poor, will produce smoke and clinker, and if Mr. McDowell is troubled with smoke he may reasonably attribute the clinker to this cause.

As the upper furnace containing the water-bars is used only as a chamber for distilling the gas from the coal, it is important that distillation should be

complete, leaving only coke to be burned on the lower grate. If it is not quite complete and the fuel is high in sulphur, clinkers will result, especially if the draft is poor.

I would suggest that Mr. McDowell look for clogged air spaces in that part of the lower bars affected. He might also see if the middle door closes tightly, and if the damper on No. 3 boiler is working well. Admitting additional air through the lower ashpit might stop the trouble if the breeching and grate bars are unobstructed.

B. H. CHESTER.

New York City.

Unnecessary Risks

The reply to "Unnecessary Risks," by Charles J. Mason in the June 4 issue, is rather inaccurate. I analyzed it and then asked an old Scotch engineer how he plugged tubes before patent expanding tube stoppers were made.

Mr. Mason says the fire in a Scotch boiler was smothered with green coal. We will allow that no carbon dioxide or other obnoxious gas was generated, and that the furnace temperature was anything you like to call it.

The diameter of Scotch boiler furnaces in those days, say 25 years ago, was rarely over 3 ft., but assume it was 4 ft.—an unheard-of size for that time and uncommon now. The tops of the fire bars were about the center of the furnace; this would allow 2 ft. from the tops of the bars to the top of the furnace. With soft coal the center fire bed would be from 6 to 10 in. thick, but call it only 8 in. thick. On top of this green coal was spread, say as thin as 2 in., and on top of the green coal planks were placed. Allowing for a 2-in. plank, we have

$$2\ ft. - (8\ in. + 2\ in. + 2\ in.) = 12\ in.$$

between the bars and furnace top at the exact center of the furnace. I would like to know how men went in a space 12 in. high "on their hands and knees."

A man of average height with the femur or thigh bone at right angles to the body measures about 2 ft. from the knee to the back. The way the job really was done (and sometimes is done to this day when the tube is so badly salted that a patent stopper will not go through) is this:

The fire was drawn; planks were laid on the bars after they had cooled a little. With the necessary plug, washer and nut, the engineer crawled in the furnace and lay on his back. The engineers or firemen on the outside pushed on his feet and slid him to the "back end" or combustion chamber. If the tube was low down he could possibly reach it from his position on his back on the planks. If he could not reach it, short pieces of plank were passed to him and these he laid on the floor of the combustion chamber to stand on. If two furnaces ran into a common combustion chamber, both fires had sometimes to be drawn but there was no danger about the job beyond the chance of a few drops of scalding water, and generally a liberal supply of old sacks would prevent any trouble from this source.

A really dangerous job, permitted or even ordered by some marine chiefs, was expanding tubes while the boiler was under pressure. My informant said he had been ordered to do this many times.

The Scotch boiler in this ship had four furnaces, two at each end, with a combustion chamber for each. The fire was drawn in the furnace below the leaky tubes and planks were laid on the grate and the combustion-chamber floor. The pressure in the boiler was 50 lb., just 10 lb. below the blowing-off pressure. With a Dudgeon tube-expander the engineer went into the back end to expand the tubes. He would take 10-min. spells; that is, he would spend 10 minutes in the back end and 10 minutes under the ventilator in the stokehold. If the tube were cut by the expander, the engineer would have been boiled alive.

L. A. SUVERKROP.

New York City.

Central and Isolated Plants

Previous discussion on this subject leads me to believe that the owners are more to blame than the engineers for the displacement of isolated plants with central-station service. We are advised to keep records of operation in plants under our charge. Records are beneficial if properly kept and interpreted, but they will not rebore a cylinder that is out of true and wasting steam, nor buy latch blocks for the old Corliss engine that has been in service since Adam was a boy.

Owners will often go to great expense in other departments to obtain the highest efficiency. Why not include the engine room; is it not one of the most important departments and worthy of the same recognition?

It is positively unjust that some engineers have to almost beg for the necessary supplies to keep the plant in successful operation. While talking with a salesman for a well known line of packing and supplies, I asked him if he had called on Mr. Smith, and he replied: "I went to the office and stated that I would like to show their engineer my line of goods and I received this answer: 'No; we buy all the supplies, and if the engineer we have cannot get along with them, we will get one that can.'"

I wonder if that same superintendent would buy stock suitable for making a $2.50 pair of shoes and then expect his men to turn out a $3.50 pair.

When the plant owners coöperate with their engineers as they do with the heads of other departments they will realize that they can furnish power cheaper than the central station can sell it.

J. M. HEALY.

Uxbridge, Mass.

Frictional Losses

In a recent issue of POWER friction load was discussed and in the case cited was found to be 24 per cent. of the total full load. Following this the article reads: "This figure was ascertained by stopping all machines and running only the shafting and belts on idle pulleys." I would like to ask was the friction load measured (1) on a cold or hot day, (2) on a damp or dry day, (3) at starting or stopping time, (4) on the first or last day of the week?

When a comparison of friction loads in different plants is made, it is essential that it be measured in each plant when the conditions are as nearly identical as possible. Otherwise no fair comparison can be made.

Those who have studied the question know that the friction load is apt to be higher in cold dry weather (in plants using leather belts); at starting time (because the lubricant in the bearings is set and stiff) and on the first of the week for the same reason.

A discussion of this subject would be extremely interesting. Why is the friction load in some plants as low as 18 per cent. while in others as high as 62 per cent.? Is not less attention generally given this subject than it warrants? How many engineers regularly take cards from their engine to ascertain the full load as well as the friction load, and how much variation in friction load in the same plant is caused by the influences above mentioned?

CHARLES F. CHASE.

New York City.

Clamps and Lacing versus Cement for Belts

In the Apr. 16 issue, J. N. Fries states in his article on belt lacing that a wire laced belt is the best. From a standpoint of safety, all belt fasteners or lacing are dangerous to the operator of a machine or to workmen in close proximity to the belt.

To be absolutely on the safe side, all leather belts should be made endless by a cemented joint. Belt cement can be obtained that will cement a belt with a loss of time of from 10 to 20 minutes, so that this delay does not amount to much. A handy man can be easily taught to do this work, and it will prove of benefit to the men, the machines and the shop in general. The belt will run smoothly, the flapping noise due to the weight of the fastener will cease, and, best of all, the workman cannot get his clothing caught

and be whirled about in the shafting.

All belting that is liable to come in contact with the workmen should be guarded up to 6 ft. from the floor, no matter how the belt is fastened together.

A. RAUCH.

Pittsburg, Penn.

Failure of Boiler Tubes

In a recent issue, W. J. Maxwell asks why boiler tubes fail. This is due in many instances, especially with water tubes, to an improper distribution of heat caused by baffle wall interference.

Flame plates and high bridge-walls produce right-angle turns of the hot gas currents, causing changes of temperature in different places. Especially if liquid fuel is burned. Air passing through the grates will be more evenly distributed to all exposed tube surface if all baffle walls, etc., are discarded.

The current then passing through in curves and bends will naturally be more effective. The bagging of tubes and leaky tube ends is caused by the chemical changes of the water inside of them and the end leaks are more or less due to excess air. My 12 years' experience with boilers, using both coal and liquid fuel, and the many tests I have seen made on tubes, boilers and furnaces in a leading university, confirm the above.

J. H. SMITH.

Austin, Tex.

Lacing Belts

The recent discussions on belt lacing interested me. A long and varied experience with belts has taught me that cementing, wire-lacing and rawhide lacing are the only correct ways to join belts. The first should be used for belts from 8 in. to 6 ft. wide and from 2 to 3 ply thick. These belts do not require tightening so frequently and cemented are very safe when driving full load. Wire-lacing should be used on belts from 1 to 8 in. wide, heavy or light double thickness. If properly laced with composition wire and the strands are hammered flush with the surface, the joint is hard to surpass. All cone-pulley belts, on lathes, for example, are better if laced with rawhide as they may be easily and safely handled.

Overhead or line-shaft belts, heavy or light double thickness, give better results when laced with wire. I have thrown wire-laced belts on pulleys many times when running full speed, and never received a scratch because the belts were properly laced and a piece of leather was used to protect my hand. The leather used, cut from an old single belt and thoroughly pliable, was circular in form and 5 in. in diameter. This hand protector must be grasped by the thumb and forefinger and under no circumstances fastened to the hand as a defective belt might catch it, causing injury. I have put the tightest of belts on pulleys in this manner.

Single belts from 1 to 8 in. should be rawhide laced. Strong, thin lacing is best. Wire works better in double than in single belts for the reason that in hammering the wire level with the belt face the leather is weakened because twice the diameter of the wire is sunk into the single ply of the leather, weakening the section, and the joint will part under sudden strain. For the best rawhide lacing of single belts the holes must be of the right size and punched in the proper places.

Of the many ways of lacing belts with rawhide I found but two which were satisfactory in saving time and giving results, the straight strand and the hinge joints. Rawhide lacing is excellent for single or double belts that have lost toughness through age, moisture or oil.

JAMES MCCLURE.

Fletcher, N. C.

Driving a Small Pipe Well

The pipe-well drill shown by George J. Little in the Apr. 2 issue is of serviceable construction except that a wooden block should be used on the driving plug to prevent it from being battered out of shape.

My experience with a similar machine teaches me that if great care is not taken, the threads on the pipe will be stripped due to the heavy blows from the driver.

JOHN THORN.

London Junction, Ont.

What Caused the Sediment?

Mr. King's trouble, mentioned in the Apr. 30 issue, is evidently due to bicarbonates in solution in the feed water. The deep red color of the deposit proves that there is a large proportion of iron. That the scale is hard to detach indicates the presence of lime and probably alumina. An analysis of the scale would be the best way to determine its composition.

These bases exist in the feed water as perfectly clear solutions of their bicarbonates. As soon as the water becomes heated in the boiler, carbon dioxide is evolved, breaking up the bicarbonates and leaving the lime, iron oxide, etc., in the form of the fine sediment referred to.

It would be best to purify the water before using. This can be done easily by adding a calculated amount of soda and moderately heating. In a small plant, the installation would probably cost more than the damage done by the scale.

A good boiler compound, or simply soda ash, should be added to the feed water. This will precipitate the impurities in a more granular condition, and frequent blowing off will remove the greater part of them. I have known of boilers being blown off every six instead of twenty-four hours when using a feed water with much lime in it.

C. T. DAWKINS.

Ashland, Wis.

Water Broke the Piston

Mr. Haight's trouble, mentioned in the May 7 issue, in my opinion is caused by water being carried over from the boilers. The fact that the piston rod was bent in one engine and the crank and crosshead were damaged in the other is proof that the piston struck something solid, such as water under compression. The piston, being weaker than the head, let go instead of knocking out the latter.

Any number of traps on a steam main will not relieve an engine cylinder of a sudden dose of water caused by the fireman pumping the boiler full. I have seen piping systems equipped with both traps and drainage systems and, in case of sudden flooding, the traps or the system were useless.

As for water getting into the piston, I cannot see how it can possibly expand and create a pressure because it could get out the same way it got in.

W. F. O'REGAN.

Salem, Mass.

Gasket Broke Filter Flanges

W. G. Freer's account of a broken condenser head in the Apr. 9 issue, reminds me of a similar experience. Two 36x72-in. water filters were being installed, and each filter was in two sections of 36 in. each, the sections being flanged and each contained thirty-two $\frac{5}{8}$-in. bolts. Rubber tubular gaskets were used having $\frac{3}{8}$ in. outside and $\frac{1}{8}$ in. inside diameters, and the ends were joined by inserting a short piece of $\frac{1}{8}$-in. soft fuse metal into each.

The erectors laid the gaskets just inside the bolt circle and then tightened the joints, but in making the last round a helper pulled too hard on the wrench and cracked the flange at the hub for a distance of four bolt-holes. The flanges had a 4-in. face and it was 2 in. from the bolt circle to the inside edge of the flange.

The trouble was attributed to a defective flange. A new section was put in and after about two hours' service a sheet of water issued from the new joint. Investigation showed a break identical with that of the recently broken flange.

I condemned the type of gasket, and contended it was responsible for both breaks, the erector arguing to the contrary and claiming the flanges were defective. Finally a sheet-rubber gasket was used, and after six months' service the joint is still tight. To my mind, the gasket acted as a fulcrum, causing undue stress on that portion of the flange which was being tightened.

L. M. JOHNSON.

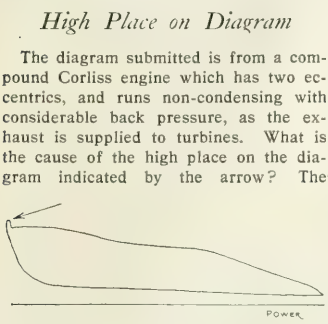
Glenfield, Penn.

Inquiries of General Interest

All Questions Must be Accompanied by Name and Address—Not for Publication

High Place on Diagram

The diagram submitted is from a compound Corliss engine which has two eccentrics, and runs non-condensing with considerable back pressure, as the exhaust is supplied to turbines. What is the cause of the high place on the diagram indicated by the arrow? The



HIGH PLACE ON DIAGRAM

trouble is not with the indicator, for it does not show on diagrams taken from other engines with the same instrument.

W. J. L.

It is impossible to say from the information given. Take a diagram from the receiver and study the difference between the receiver pressure and the steam line of the diagram at this point. This study can be facilitated by taking the motion for the paper drum of the indicator from the eccentric or valve motion instead of from the crosshead, which will spread out this portion of the diagram and make it easier to analyze.

Lining up an Engine

Without disconnecting any parts of an engine, how can it be ascertained whether the crankshaft is at right angles to the center line of the cylinder?

W. H.

Stretch a fine braided line over the engine parallel to the crankshaft and stretch another such line, just touching the first one, parallel with the center line of the cylinder. The longer the lines the better, provided they are set taut and firm. With a light pine rod or tram, locate equal distances on the line parallel with the crankshaft, each side of its intersection with the line which is parallel with the cylinder center line. Then if the shaft and center line of cylinder are at right angles to each other, any point on the line parallel to the cylinder center line will be equidistant from the points first laid off on the line parallel to the shaft.

Instead of taking an equal distance on each side of one of the lines, the angle between them can be tested by laying off a point on each at distances from the point of intersection in proportion of 3 to 4 and testing the length of the hypothenuse, which should be 5 to the same scale if the two lines are at right angles with each other. It is better, however, where space will permit, to check the angles as by the first method, and even better to test the equality of all four angles made by the cords at their point of crossing. In setting the lines parallel with the shaft or center line of cylinder, in each case select two points of reference that are as far apart as possible. The line intended to be parallel with the shaft may usually be set by plumbing direct over the shaft center points, or by horizontal measurements to plumbings taken with proper allowance for any differences in diameters at the points of measurement.

The line parallel to the center line of cylinder may be located in a similar manner with reference to any bored or turned-off part of the cylinder which is concentric with the center line of the cylinder.

Gearing a Motor

Is it well to use a pair of ordinary cast-iron spur gears for a drive from a 75-hp. motor making 715 r.p.m. to a shaft which is to make 85 r.p.m.?

J. Q. A.

It would be better to use an adjustable intermediate gear than to depend upon adjusting the position of the motor to preserve proper distance between centers. On account of the high speed of the motor, cast iron would not be as suitable for the spur gear which meshes with the gear on the motor, as cast steel, or bronze, or a wheel with wooden teeth, all of which withstand vibrations better than cast iron. It would be better still to employ spiral gearing or some form of smooth running gear wheels.

Pressure in Discharge Line

When a pump is not running, what pressure should be indicated by a gage when connected with the pump's discharge line to a tank, at a point which is 125 ft. below the tank, with 10 ft. depth of water in the tank? What causes the gage to indicate more pressure when the pump is discharging to the tank and upon what does the increase depend?

A. T.

When the pump is at rest and there is no leakage or discharge from the line, the total head at the gage would be 125 + 10 = 135 ft. The pressure per foot of head being 0.433 lb. per square inch the gage should indicate

$$135 \times 0.433 = 58.455$$

or practically 58½ lb. per square inch. When the pump is discharging to the tank the pressure indicated by the gage will be increased by the amount of pressure lost by friction beyond the place where the gage is attached. The amount of increase depends upon the size and length of the line, the fittings in the line and the velocity at which the water is pumped through the line.

Friction of Elevator Plunger

When the plunger of a plunger-type elevator is all the way down in the cylinder, does the hydraulic pressure against the cylindrical surface of the plunger create frictional resistance to starting the plunger in motion or tend to retard the plunger while it is in motion?

H. T.

No; fluid friction is independent of the pressure of the liquid.

Effect of Boiler Patch

How much reduction should be made in the pressure carried on a 60-in. diameter by 16-ft. boiler on account of the shell having a patch 15 in. wide by 18 in., measured girthwise of the boiler?

H. F.

If the patch has no corners less than 6 in. radius, is made of soft iron well shaped to fit up against the boiler shell and has a single row of rivets equal to the girth-seam riveting of the boiler, then the presence of a repair patch should not require any reduction in pressure to be carried on the boiler.

Tube Expanders

Is it good practice to use a taper plug for expanding the ends of boiler tubes? Is a roller expander better, and, if so, why?

H. M.

It is not good practice to expand boiler tubes by swedging their ends with a taper plug as it crystallizes the tube ends and produces irregular bearing of the tube around the tube-sheet hole. A roller expander is better as it stretches the tube gradually and presses the inequalities of the tube up to uniform bearing all around the tube-sheet hole.

Study Questions

This Week's Questions
Last Week's Answers

31. An electrician making up a bank of resistance with a certain number of incandescent lamps (less than 100), found that if he arranged them in three rows he would have one left over, in four rows two left over, in five rows three left over and in six rows four left over. How many lamps had he and in how many rows could he arrange them with none left over?

32. A water tower 200 ft. high is encircled exactly five times by a spiral stairway from the ground to the top, the length of which measured along the wall of the tower is 282 ft. 10 in. What is the diameter of the tower?

33. How many degrees above absolute zero is each of the following temperatures: 60, 100 and 247 deg. F., and 0 and 100 deg. C.?

34. What was the original temperature of a pound of cast iron (specific heat = 0.13) if its immersion in 2 gal. of water at 62 deg. F. raises the temperature of the water to 71 deg.?

35. How much does a brick chimney weigh, 32 ft. high, with walls 8 in. thick throughout, if it measures 40 in. square on the outside at the top and 40 in. square on the inside at the bottom, assuming the brickwork to weigh 120 lb. per cubic foot?

Answers to the above will appear in the next issue. Answers to last week's questions follow:

26. On one side the crank and connecting-rod are in a straight line so that 7½ ft. is the sum of their lengths. On the other side a right triangle is formed by the connecting-rod as the hypothenuse, the crank as the altitude and the crosshead to axle distance as the base.

Let

x = Length of the crank;

$7\frac{1}{2} - x$ = Length of the connecting-rod.

Since the hypothenuse of a right triangle equals the sum of the squares of the other two sides,

$$(7\tfrac{1}{2} - x)^2 = x^2 + (6.125)^2$$

$$56.25 - 15x + x^2 = x^2 + 37.5156$$

$$15x = 18.7344$$

$$x = 1.24896$$

or closely 1¼ ft. or 15 in.

$$7\tfrac{1}{2} - x = 6.25104$$

or closely 6¼ ft. or 75 in.

27. Since a cube is the form of a closed rectangular tank having the least surface area for a given volume, each half holds its maximum and it naturally follows that a half a cube is the form of an open tank to hold the most. Certainly the base should be square and it can be shown that the height should be one-half of one edge of the base.

Let x = one edge of the base and $\frac{x}{2}$ = height. Then the volume is

$$x \times x \times \frac{x}{2} = \frac{x^3}{2} = 8 \text{ cu.ft.}$$

and

$$x^3 = 16;$$

$$x = 2.5198 \text{ ft.};$$

$$\frac{x}{2} = 1.2599 \text{ ft.}$$

The tank should therefore be 2 ft. 6¼ in. by 2 ft. 6¼ in. on the bottom and 1 ft. 3⅛ in. high and will have a total surface area of

$$2.5198 \times 2.5198 + 4\ (2.5198 \times 1.2599) = 19.048 \text{ sq.ft.}$$

To prove that this tank requires the least material for its volume, try other values for the height each side of the one determined and figure the corresponding base dimensions and it will be found that the total surface areas will exceed that given above.

28. As explained in answer No. 24,

1 deg. F. = 5/9 deg. C.

1 deg. C. = 9/5 deg. F.

Account must be taken of the different zero positions—on the Centigrade scale at freezing point and on the Fahrenheit scale 32 deg. below freezing. Therefore, after converting a Centigrade reading to Fahrenheit, if above zero 32 deg. must be added, and if below zero, 32 deg. subtracted, and a Fahrenheit reading before being converted to Centigrade, if above zero, must have 32 deg. subtracted and if below zero 32 deg. added.

Deg. F.		Deg. C.	Deg. C.		Deg. F.
5	=	−15	1	=	33.8
14	=	−10	−30	=	−22
41	=	5	−25	=	−13
68	=	20	90	=	194
158	=	70	120	=	248
266	=	130			

29. The section of the bar is 2 × ½ = 1 sq.in., the length 36 in., making the volume 36 cu.in. A cubic foot (1728 in.) weighs 480 lb.; then 36 cu.in. weighs

$$\frac{480}{1728} \times 36 = 10 \text{ lb.}$$

30. One gallon of water weighs 8.3356 lb.

$$Hp. = \frac{\text{work in. ft.-lb.}}{\text{time in min.} \times 33{,}000} =$$

$$\frac{108{,}000 \times 8.3356 \times 250}{60 \times 33{,}000} = 113.6672$$

Errata: In the answer to question 14, June 4, the weight of the ladder was inadvertently taken as 62 lb. when the original question gave it as 60 lb., and the length of the ladder as 25 ft. when it should have been 30 ft. These inaccuracies affected equations (a) and (c) which should have been

$$60 \times 6.14085 = 368.451 \qquad (a)$$

and

$$30 \times \sin. 65 \text{ deg. } 50 \text{ min.} = 30 \times 0.91236 = 27.3708$$

and the moment

$$X \times 27.3708 \qquad (c)$$

making the correct answer

$$(X \times 27.3708) - 368.451 - 1535.2125 = 0$$

$$X = \frac{1903.6635}{27.3708} = 69.55 \text{ lb.}$$

Errata: In the answer to question 19 in the issue of June 11 an error was made in reducing the equation for v^2. It should have been

$$v^2 = \frac{1737.794}{0.9627} = 1805.1251$$

$v = 42.48$ ft. per second.

New York State Convention of the N. A. S. E.

The seventeenth annual convention of the New York State Association of the National Association was held at Yonkers, June 14, 15 and 16, with headquarters at the Getty House.

More than one hundred firms occupied booths in the main hall of the armory, which was tastefully decorated and arranged for the largest mechanical exhibit in the history of the state association. The meetings of the delegates were held in an adjoining hall, making it convenient for them to visit the display. About fifty delegates and alternates were present besides delegates from associations in all parts of New York State and New Jersey. The exhibit proved of great interest, and was largely attended during the three days.

The convention was formally opened at ten o'clock on Friday morning. Charles Graham, chairman of the local committee, called the body to order and introduced Mayor James T. Lennon, who made a warm speech of welcome. National President Edward H. Kearney responded, and spoke upon the general topics of the N. A. S. E. Nathan A. Warren, president of the Chamber of Commerce, talked interestingly of Yonkers, and James R. Coe, national state deputy, responded. Campbell Scott, superintendent of the Otis Elevator Co., then extended an invitation to visit the company's plant, which was acknowledged by State Vice-president George O. Kaley. Following the appointment of several committees, the meeting adjourned until Saturday morning.

At the remaining sessions the business of the convention was rapidly and harmoniously dispatched. Financially the organization is in a healthy condition. A resolution was passed to have one delegate to every twenty-five members instead of fifty as heretofore, the object being to get a bigger representation. A small assessment was placed upon each member of the association connected with the state association for the advancement of the educational work. Edward Lee was

elected a committee of one to officiate with the labor and industrial committee at Albany to further the interest in the license movement, and a sum not to exceed five hundred dollars was appropriated for this purpose.

On Friday at noon the delegates and guests inspected the Otis Elevator Co.'s works. Lunch was served and the visitors were pleasantly entertained. That afternoon many of the guests were invited to the home of Tim Healy, president of the Firemen's Association, where they were heartily received and were served a good dinner. In the evening an enjoyable vaudeville entertainment was given in the exhibition had by the New York "Bunch."

Sunday afternoon there was a sail on the Hudson River with refreshments, music and dancing.

The election of state officers resulted as follows: George O. Kaley, president; Charles Fradenberg, vice-president; Edward Pruyn, secretary; William Downes, treasurer; George Harris, conductor; James Fitzgerald, doorkeeper; Joseph Gregory, chaplain; E. T. Gilroy, state deputy; Past President Charles Schabecker, special state deputy.

It was unanimously voted to hold the next convention at Yonkers in June, 1913.

NATIONAL PRESIDENT AND STATE OFFICERS OF THE N. Y. STATE N. A. S. E.

THE EXHIBITORS

Albany Lubricating Co., Alberger Pump & Condenser Co., Alsen Cement, American Engine Co., American Huhn Metallic Packing Co., American Steam Gauge & Valve Manufacturing Co., American Tool & Machine Co., V. D. Anderson Co., Armstrong Cork Co., Ashton Laird & Co., Boig & Hill, Buhne Metallic Packing Co., Chapman Valve Manufacturing Co., Clement Restein Co., Cling Surface Co., Cochrane Heaters, C. T. Coe Co., Coralline Drug & Chemical Co., Crandall Packing Co., M. T. Davidson Co., Dearborn Drug & Chemical Works, Dodge Manufacturing Co., Duryea Manufacturing Co., Eddy Valve Co., Engineers Mill & Supply Co., Erie City Iron Works, Estate of Edward R. Laden, Fuel Engineering Co., Garlock Packing Co., Green Fuel Economizer Co., Greene, Tweed & Co., Hawkeye Compound Co., Heine Safety Water Tube Boiler Co., Hewes & Phillips Iron Works, Homestead Valve Manufacturing Co., Home Rubber Co., International Acheson Graphite Co., Iron Works Co., Jefferson Union Co., Jenkins Bros., Keystone Lubricator Co., Knickerbocker Smokeless Coal, Lagonda Manufacturing Co., Leslie Co., Samuel Lewis, Lunkenheimer Co., McLeod & Henry Co., W. B. McVicker Co., Manning, Maxwell & Moore, H. W. Johns-Manville Co., J. O. Meara, Inc., *National Engineer*, National Flue Cleaner Co., New York Belting & Packing Co., Ohio Injector Co., Otis Elevator Co., J. E. Pawson Co., Peerless Rubber Co., Philadelphia Grease Manufacturing Co., Pitts & Kitts Manufacturing & Supply Co., William Powell Co., POWER, Power Specialty Co., Platt Iron Works, *Practical Engineer*, John R. Robinson, A. Roebling's Sons Co., Roto Co., Joseph C. Ryan, Schaeffer & Budenberg Manufacturing Co., Sherwood Manufacturing Co., Shipley Construction & Supply Co., Skinner & Connolly, Smooth-On Manufacturing Co., *Southern Engineer*, C. E. Squires, Murphy Stoker, J. L. Trumby Co., Under-Feed Stoker Co. of America, Vulcan Soot Cleaner, Washburn & Granger, F. W. Webb Manufacturing Co., Westchester Lighting Co.

Kentucky N. A. S. E. Convention

The local committee at Owensboro, where the tenth annual convention of the Kentucky State association of the National Association of Stationary Engineers was held, did full justice to the reputation for hospitality which the Kentuckians justly enjoy. Although the business part of the convention occupied only two days, June 14 and 15, many delegates and guests were on the grounds so that the supplymen's exhibit was opened a day earlier. The exhibit and the business meetings were held in the Owensboro armory, which was ideal for both purposes.

The convention was opened by J. H. Oelze, state president, at 10 a.m., Friday, June 14. After the prayer offered by the Rev. Lewis Powell, Mayor Lambert welcomed the members and guests to Owensboro. In responding, Fred Raven, the national secretary, told of the work of the association and its growth. George H. Cox then spoke on "Our City," enlarging upon the physical, financial and social advantages of Owensboro. After the various committees were appointed by President Oelze, the exhibit hall was formally opened by Charles Cullen, vice-president of the Central State Exhibitors Association.

The afternoon session was taken up entirely with organization business, such as reports of the various officers and committees. The license-law committee was continued with the same personnel and instructed to use every legitimate means to increase public interest toward securing the enactment of a competent law.

For the evening the delegates and visitors were the guests of Kentucky Association No. 9 on its annual moonlight excursion on the Ohio River.

At the Saturday morning session reports were received from the various standing committees and numerous addresses were made. W. H. Corwin, Kentucky Association No. 2, Ashland, spoke on "The Benefits To Be Derived from a License Law in Kentucky." Frederick L. Ray, Kentucky Association No. 1, Louisville, delivered two papers, one entitled, "Self-Reliance, the Power Behind Many Successful Lives," in which he cited many examples of success achieved in the face of almost heart-breaking handicaps, simply through self-reliance, and one on "Our Educational Work," outlining a system of suitably graded questions which the author proposed should be published each month in the official organ of the association, *The National Engineer*. The questions were to be divided into three grades, elementary, intermediate and advanced, so that men of all stations could participate and the winners in each grade were to be awarded cash prizes.

E. H. Breidenbach, Kentucky Association No. 9, Owensboro, who is manager of the municipal lighting plant and waterworks, gave an illustrated lecture on "Water Purification" in which he described the methods employed at the plant of which he has charge and which he illustrated with numerous photographs of the plant itself.

Charles D. Scott, Kentucky Association No. 8, Henderson, gave a brief address on "Engineering in a Small City," in which he told of the handicap of operating engineers in small communities where opportunities for advancement are scarce.

Hopkinsville was selected as the meeting place for the next convention and National Secretary Raven installed the following officers, elected for the coming year: J. L. Shrode, Hopkinsville, president; C. Carroll, Louisville, vice-president; J. R. Morris, Hopkinsville, secretary; E. Kochenrath, Louisville, reëlected treasurer; J. H. Stamper, Lexington, conductor; J. N. Draper, Henderson, doorkeeper; T. E. Hopkins, Louisville, state deputy.

The meeting then adjourned and the delegates and guests assembled in a large open lot adjacent to the armory where the annual barbecue and fish-fry was held at 1 p.m.

In the afternoon an automobile ride was taken to various parts of the city and in the evening an entertainment was given by the Central States Exhibitors Association.

The following members of the Central States Exhibitors Association had representatives in attendance and suitable exhibits of their products: American Steam Gauge & Valve Manufacturing Co., V. D. Anderson Co., Crandall Packing Co., Dearborn Drug & Chemical Co., Garlock Packing Co., Greene, Tweed & Co., Hawk-Eye Compound Co., Hills, McCanna Co., Home Rubber Co., Jenkins Bros., H. W. Johns-Manville Co., Keystone Lubricating Co., Lunkenheimer Co., Osborne Valve & Joint Co., William Powell Co., POWER, Schaeffer & Budenberg Manufacturing Co., C. E. Squires Co., United States Graphite Co. The following associate members were also represented and had exhibits: Diamond Power Specialty Co., W. H. Niell Co., Lagonda Manufacturing Co., Guenther-Wright Machine Co., James Clark, Jr., Electric Co.

International Electrical Congress

The officers for the International Electrical Congress, to be held in San Francisco at the Panama-Pacific Exhibition in 1915, have been announced. The committee of organization: Charles P. Steinmetz, president; Arthur E. Kennelly, vice-president on program; C. O. Mailloux, vice-president on international relations; W. D. Weaver, vice-president on organization; Henry A. Lardner, vice-president on Pacific Coast relations; Edward B. Rosa, secretary, and Preston S. Millar, treasurer and business manager. These officers constitute the executive committee and were appointed by President Dunn, of the American Institute of Electrical Engineers.

In addition, President Dunn has appointed other institute members, who are also members of other national bodies, to coöperate with the executive committee in the work of the congress. Among the associations so represented are the American Electric Association, American Electrochemical Society, Association of Edison Illuminating Companies, Association of Railway Electrical Engineers, Canadian Electrical Association, Empire State Gas & Electric Association, Franklin Institute, Illuminating Engineering Society, National Bureau of Standards, National Electric Light Association and Society for the Promotion of Engineering Education. The committee of organization includes members appointed from the Pacific Coast and 56 members-at-large.

Coaling the "Moltke"

Before starting home to Kiel, the German squadron was coaled at its anchorage in the Hudson River. It was a small job to fill the bunkers of the "Stettin" and the "Bremen," but it took 200 of the German tars all day to put the 3600 tons into the "Moltke" necessary to make the homeward voyage.

On each side of the ship two big derricks extended over the coal barges, with six pulleys each with cable connections. The sacks were lowered from these pulleys to the barges, filled and then hooked and hoisted by electric winches on board, each having an individual motor. As each sack swung free of the sides of the vessel, which are covered with canvas and padded to insure them against scratches, two sailors seized it and gave it a yank which sent its contents down a chute to the bunkers.

Fire at Newark Plant

Four substations of the Public Service Electric Co., at Newark, N. J., on June 13 were shut down by a fire which burned out the cables in the company's power house. Several municipalities supplied with light and power from these substations were cut off for several hours.

It was at first thought that a 500-kw. transformer had blown out, but Manager Farrand said it was impossible to say definitely what caused the trouble. The cables rendered useless were in a pit beneath a big switchboard. The transformer is of the oil-cooled type and a sudden flash of electricity ignited and spattered the oil.

An idea of the intensity of the heat in the cable pit is gained from conditions found after the fire. The three-ply copper cables were bound by steel tape, which was encased in a lead-pipe covering and in turn covered with asbestos. The heat had melted the lead covering and so affected the cables as to make them resemble, in the words of Manager Farrand, "a bunch of spaghetti."

Burst Flywheel

At 2:30 a.m., June 11, a 15-ton flywheel of the stationary engine in the Delaware & Hudson Ry. shops, Green Island, N. Y., burst, but luckily no one was injured. The wheel was 14 ft. in diameter, with a 36-in. face. During the day 500 men are employed about the shops, but at the time of the accident only the engineer and his two assistants were on watch.

From some unknown cause the main belt of the engine broke and wound around one of the pipes running across the engine room, pulling the pipe down and breaking the flywheel in several places. Large pieces of the wheel went through the building, landing several hundred feet away. One piece went through the roof and another tore up several feet of railroad track.

This is the first accident to occur in these shops. The company immediately had a new wheel made and fitted. The damage was $1000.

Increased Power at Rossland, B. C.

Anticipating the electrification of the Canadian Pacific Ry. from Castlegar to Rossland, B. C., the direction of the West Kootenay Power & Light Co. will increase the capacity of the No. 2 plant at Bonnington Falls. This plant has two units of 6600 hp. each, to which an 8000-hp. unit will be added, making 21,200 hp. available. When the plant was built space was allowed for two additional units.

With the increased power all of the trains on the Columbia & Western branch of the Canadian Pacific Ry. can be handled with power to spare. Before the road can be electrically operated, poles for the trolley wires will have to be erected. Presumably, the road will use the overhead rather than the third-rail system. The latter, besides being a menace to life, would hardly work advantageously where there is so much snow. It will be several months before this section of the road is ready for operation.

In 1911 America produced 83,000,000 barrels of petroleum.

Europe Interested in Panama Exposition

John Hays Hammond, chairman of the American commission which went abroad to arouse the interest of European nations in the Panama-Pacific Exposition at San Francisco in 1915, has returned much pleased with the result of his trip.

"I was especially pleased with our reception in Russia," he said. "For a time I thought our efforts there would not equal our success in southern Europe on account of the slight friction between the two countries. Now Russia is in line with the rest and will be represented at the exposition.

"All of the European nations have already made preparations for representation, and we had no trouble in interesting them."

Increased Use of Water Power

Of the 30,000,000 hp. used in industrial and public-utility enterprises, reports the Commissioner of Corporations, 6,000,000 hp. is now developed by water. At a conservative estimate, this saves 33,000,000 tons of coal per year. Several million more horsepower could profitably be developed from the same inexhaustible source.

Of the 6,000,000 hp. now developed, 3,270,755 is generated for sale (that is, not for private use, as in manufacturing) by companies or groups of interests having 50,000 hp. or more actually developed or under construction. The report concludes that it is not feasible to regulate the price of water power by itself, but rather to control the sites, or their uses.

SOCIETY NOTES

The International Association of Municipal Electricians will hold its annual convention at Peoria, Ill., on Aug. 26 to 30.

The annual meeting of the Institute of Operating Engineers will be held at the Engineering Societies Building, New York, Sept. 6 and 7. Details will be announced as the program takes more definite form.

The June bulletin of the Institute of Operating Engineers announces that the second annual meeting will be on Sept. 6 and 7. At the July 2 meeting, William A. T. Willink, master operating engineer, will read a paper on "Efficiency in Steam Boiler Furnaces."

The sixteenth annual convention of the Connecticut State Association of the National Association of Stationary Engineers will be held in Bridgeport, June 28 and 29. The committee is hard at work making final arrangements. The mechanical exhibit will be the largest the state has yet seen and there will be an unusually big attendance of delegates. A good program of entertainment has been completed.

At the June 20 meeting of the American Society of Engineer Draftsmen in the Engineering Societies Building, New York City, William B. Harsel, the vice-president, will read a paper on "Sheet Metal Industris." Prof. William Noyes, of the Teachers College, Columbia University, will lecture on "American Woods for Commercial Purposes," illustrated by the stereopticon. The public is invited to attend.

SCHOOL NOTES

The dinner commemorating the twenty-fifth anniversary of the founding of Pratt Institute, held in the Twenty-third Regiment Armory, Brooklyn, N. Y., June 15, was attended by about 1800 graduates and former and present students.

Prof. Levi L. Conant, for the last year acting president of the Worcester Polytechnic Institute, will continue in that capacity the coming year. Prof. Z. W. Coombs, acting secretary since the death of Secretary J. K. Marshall, three years ago, has been appointed permanent secretary by the trustees. John Harland Nelson, formerly head of the department of applied mechanics, of the Case School of Applied Science, in Cleveland, will occupy a similar position here next year. Prof. H. C. Ives, formerly assistant professor of railroad engineering, has been advanced to a professorship.

PERSONAL

Nathan Owitz, of New York City, has been made manager of the Wheeler Condenser & Engineering Co.'s Cincinnati office.

S. R. Guggenheim has been chosen a director of the International Pump Co. in place of Benjamin Guggenheim, who was lost on the "Titanic."

Charles A. Moore, president of Manning, Maxwell & Moore, Inc., recently returned from Europe after an absence of nearly two years. Mr. Moore is in excellent health and is resuming his attention to business.

George F. Murphy has been appointed Eastern sales representative of the Busch-Sulzer Bros. Diesel Engine Co., of St. Louis, to succeed W. R. Haynie, with offices at 30 Church St., New York City.

Joseph V. Woodworth, consulting engineer at the New York office of the Taft-Peirce Manufacturing Co., Woonsocket, R. I., resigned recently to accept a similar position with the Boston Pressed Metal Co., Worcester, Mass., with offices in the Tribune Building, 154 Nassau St., New York City.

Joseph H. McNeil, chief inspector of boilers and chairman of the Board of Boiler Rules of the State of Massachusetts, has tendered his resignation, to take effect June 30, when he will become chief inspector of the Boston department of the Hartford Steam Boiler Inspection & Insurance Co.

Mr. McNeil has had a wide and valuable experience as an engineer and inspector. He was born, February, 1865, at Charlottetown, Prince Edward's Island, where he was educated in the public schools and Prince of Wales College. He served six years in the mechanical and executive department of the Prince Edward Island Ry. machine and boiler shop. After several years of stationary-engineering practice, he entered the merchant-marine service, where he became a chief engineer of ocean-going vessels, under license by the United States Government and the British Board of Trade.

In June, 1898, he was appointed an inspector of boilers and examiner of engineers for Massachusetts. In a reorganization of the boiler department in 1906 he took the civil-service examination and, ranking the highest, was appointed chief inspector of the department. Mr. McNeil's training was such that he saw great possibilities in an improved method of treating state supervision of boilers, and became a strong supporter, if not the very father, of the laws of 1907 which created the Board of Boiler Rules.

When the law was passed and the rules formulated, they were so much in advance of other legislation and supervision that they created some opposition among owners and boiler builders, but the administration of the rules has been so fairly and justly performed with Mr. McNeil as the chief executive that they are now looked upon as being equitable by the different interests of the state in every way and are being adopted with but few changes by other states and in one city even as far away as Manila, Luzon Island. Mr. McNeil is a member of a number of engineering societies, including the American Society of Mechanical Engineers.

BOOKS RECEIVED

PRACTICAL AERONAUTICS. By Chas. B. Hayward. American School of Correspondence, Chicago, Ill. Cloth, 769 pages, 6¼x9½ in.; fully illustrated; indexed.

AERIAL OR WIRE ROPE WAYS. By A. J. Wallis-Tayler. D. Van Nostrand Co., New York. Cloth, 246 pages, 6¼x8½ in.; 155 illustrations; indexed. Price, $3.

AN INTRODUCTION TO THE STUDY OF FUEL. By F. J. Bristoe. D. Van Nostrand Co., New York. Cloth, 269 pages, 5½x8¾ in.; 61 illustrations; indexed. Price, $3.

PRACTICAL MATHEMATICS AND GEOMETRY FOR TECHNICAL STUDENTS. Part II—Advanced Course. By Edward L. Bates and Frederick Charlesworth. D. Van Nostrand Co., New York. Cloth, 776 pages, 4½x7¼ in.; 300 illustrations; indexed. Price, $1.50.

Moments with the Ad. Editor

You remember the story of the German who was scared half to death because he was being followed by a loudly barking bull dog—

A friend stopped him and said, "Don't be afraid, Heine; when a dog is wagging his tail like that one, he won't bite you. Don't you know that?"

And Heine tremblingly replied, "Sure, *I* know it, but does the *dog* know it?"

You see there are cases where a complete understanding is absolutely necessary—and that's the reason for these little talks on advertising.

It has become highly important for every man of influence in this country to understand something about advertising—

And that applies to all you men who are responsible for that most fundamental element of modern industry—the generation and transmission of power.

Here's one way to look at it:

Supposing a manufacturer today put out a device for use in power plants. Supposing it was bad in principle, design and construction and wouldn't do the work he claimed for it. Supposing he wanted to advertise it in "Power" and sell it to you readers of the paper—

What would happen?

Well, in the first place "Power" wouldn't print his ad at any price—nor would any other reputable paper.

In the second place if he *could* get an ad before you, the chances are 100 to 1 that you would see the flaws in his illustrations and claims and laugh at him.

Or you would make him show you his product and prove its merit before you'd buy it.

But even if he did succeed in selling some of his appliances and they failed to do the work, then the ones who had been "stung" would advertise the fact broadcast and the manufacturer would go to the wall.

That's just about the chance a fake manufacturer would have in these days of modern advertising—

And it gives you an idea of the great *protective* value of advertising.

The advertiser of today makes his space pay him by making it pay you to buy his article—and that's the only way in the world any advertising can be made to pay.

Which is the chief reason why it will pay you to read the ads in "Power" and buy the goods advertised.

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